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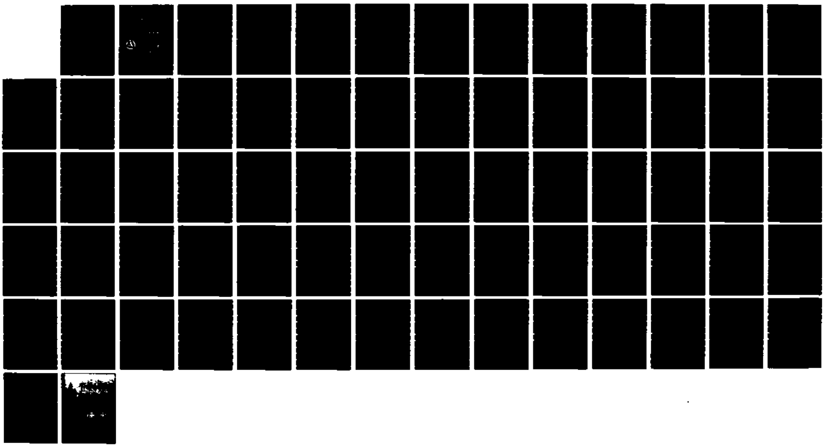

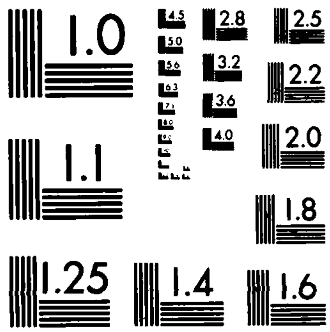
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USAFETAC/TN-83/001

AN AID FOR USING THE REVISED UNIFORM SUMMARY OF SURFACE WEATHER OBSERVATIONS (RUSSWOs)

JUNE 1983

Approved For Public Release; Distribution Unlimited

UNITED STATES AIR FORCE
AIR WEATHER SERVICE (MAC)
USAF
ENVIRONMENTAL
TECHNICAL APPLICATIONS
CENTER
SCOTT AIR FORCE BASE, ILLINOIS 62225

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USAFETAC/TN-83/001, An Aid for Using the Revised Uniform Summary of Surface Weather Observations (RUSSWOs), June 1983, is approved for public release. There is no objection to unlimited distribution of this document to the public at large, or by the Defense Technical Information Center (DTIC) to the National Technical Information Service (NTIS).

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Patrick J. Breitling

DR. PATRICK J. BREITLING
Chief Scientist

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REPORT DOCUMENTATION PAGE

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Climatology	Ceiling-Visibility	Weather Conditions
Surface Winds	Relative Humidity	Monthly Climatology
Temperature	Station Pressure	RUSSWO Guide
Precipitation	Extreme Max & Min Temperature	USER's Guide
Daily Temperature	Sea-Level Pressure	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Technical Note discusses the six-part statistical summary of the USAF Environmental Technical Applications Center's standard climatological data summary: Revised Uniform Summary of Surface Weather Observations and outlines use of the climatological document through a series of example exercises. The six parts covered are: (A) Weather Conditions and Atmospheric Phenomena; (B) Precipitation, Snowfall, and Snow Depth; (C) Surface Winds; (D) Ceiling Visibility, Sky Cover; (E) Daily Max, Min, and Mean Temperatures, Psychrometric

(Cont'd)

Block 20 Continued:

- Dry vs Wet-Bulb Temperature, Mean & Standard Deviation - (Dry Bulb, Wet Bulb, & Dew Point), & Relative Humidity; and (F) Station Pressure and Sea-Level Pressure.

PREFACE

This technical note (TN) is designed to acquaint forecasters, primarily at the detachment level, with the use of the Revised Uniform Summary of Surface Weather Observations (RUSSWO) which is prepared by the United States Air Force Environmental Technical Applications Center (USAFETAC).

A thorough familiarity with the RUSSWO will allow the detachment to satisfy many of its requirements for local climatological information. Assistance in providing more rigorous climatological information than can be determined from the RUSSWO can be obtained through an AWSR 105-18 request.

This TN includes a brief explanation of each part of the RUSSWO together with reproductions of selected summaries. Exercises that stress procedures for extracting key climatic data are included for each reproduced climatological data summary. Some exercises introduce techniques for obtaining data that are not tabulated directly in the RUSSWO. In most cases, the page of exercises for a particular summary faces the summary to facilitate study.

Although this TN will have diminished applicability for a new RUSSWO format expected in the 1984 calendar year time-frame, it will be relevant for current RUSSWOs which will not be updated for a number of years. Additional parts that the new RUSSWOs will contain will be an hourly breakout of thunderstorm occurrences, weather conditions versus wind direction, cross wind summaries, and heating and cooling degree days summaries. The new RUSSWO will no longer be produced on preprinted forms but will be machine generated on computer paper.

This Technical Note supersedes AWS Pamphlet 105-1, 30 November 1966.

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ELLSWORTH AFB SD/RAPID CITY

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Chapter 1

INTRODUCTION

1.1 Background

The Revised Uniform Summary of Surface Weather Observations (RUSSWO) contains six parts, A through F. Each part is preceded by a short explanation; however, additional clarification, not appropriate for inclusion in the RUSSWO is usually required. This technical note is intended to fill that requirement and to show by means of specific exercises how to use the RUSSWO.

1.2 Quality Control

Before a RUSSWO is produced, the observations in USAFETAC's computerized data base are audited to determine if there are enough observations of the various meteorological elements to warrant RUSSWO production. Where possible, missing data are recovered from the original, hard-copy station records or are computed from other reported elements. Once we have an adequate data base in terms of quantity, the observations are checked for quality. Various quality control techniques are used. Some examples are trend analyses for temperatures and pressures, checks for incompatibility of related values, and filters for removing absolute errors. Thus, much effort is made to ensure a good data base is used for RUSSWO production.

1.3 Period of Record

Different parts of the RUSSWO are likely to be based on different periods of record. USAFETAC's current policy is to use the latest 10-year period of record for summaries based on hourly observations, and to use the maximum available period of record for those summaries based on the "Summary of the Day" or daily observations. Because of the differing periods of record used, care must be exercised in comparing similar values from different summaries.

1.4 Definition and Interpretation

The terms "mean percent of time" and "mean percent of observations" are synonymous as used in this TN because the number of hourly observations in nearly all cases is the same as the number of hours in the months of years involved. It needs emphasizing, nonetheless, that only HOURLY observations are used in summaries listed as derived from hourly observations. However, ALL observations (hourlies, specials, "Summary of the Day," etc.) are used in summaries listed as derived from daily observations. A long period of record will usually overcome the disadvantages of not using all of the observations for some summaries; but a few apparent inconsistencies can be reconciled if this fact is kept in mind.

Many stations for which RUSSWOs are now prepared operate less than 24 hours per day and less than 7 days per week. Some RUSSWO parts can be significantly affected by data processed from these less than full time stations with data shortfalls.

Throughout all parts of the RUSSWO containing percentage frequencies of occurrence, the lack of an entry in a block signifies either that no occurrences were observed during the period of record for the summary or that data were missing. The recording of ".0" or "0.0" is an indicator that a phenomenon was observed so infrequently that it is "0.0" in the mean after rounding to the nearest tenth of a percent.

Several terms from statistics are used throughout this TN. They are defined here so that we may have a common vocabulary with which to work.

Mean. The mean is the arithmatic average of all the values of concern. It is found by simply adding all the values and dividing by the number of values added. Symbolically we write the mean as

$$\bar{x} = \frac{\Sigma x}{N}$$

Where x is an individual value and N is the total number of values.

The mean is also known as the expected value of the variable.

Standard Deviation. The standard deviation is defined by

$$\sigma_x = [(\Sigma x^2/N)-(\Sigma x/N)^2]^{\frac{1}{2}}$$

The standard deviation gives a measure of the dispersion on the variability of the quantity of concern about its arithmatic mean. The larger the standard deviation, the greater the variability.

Bivariate Distribution. A bivariate distribution gives the joint distributions of two related variables. A classic example from the RUSSWO is the bivariate distribution of ceilings and visibilities. Each row and each column of a bivariate distribution is a frequency distribution. Joint frequencies are found at the row-column intersections.

Frequency. In statistics the frequency is the number of times a given con occurs. We often express this as PERCENTAGE FREQUENCY wherein we give t frequency (number of occurrences) as a percent of all possible occurrences our sample. Hence, if snow fell on five out of 100 days we could express t "Percentage Frequency of Occurrence" of snow as 5 percent over the 100 c period of record.

Probability. If f is the frequency of a specified event or condition, and N is the number of all events, the f/N is the probability. Probability can be expressed as a fraction or a percentage. Its range is limited by definition from 0 (0 Percent) to 1 (100 Percent). When expressed as a percentage, we refer to the "Percent Probability" or "Percentage Probability."

A fuller discussion of statistical methods as applied to climatology can be found in AWS TR 77-267 (1977), in Panofsky and Brier's (1968) classic text, and in numerous other sources. The reader is encouraged to refer to these references.

1.5 Station History

On a page preceding the Weather Conditions (PART A) write-up in a RUSSWO, is the "Station Location and Instrumentation History" sheet (see Figure 4.1, page 23). Significant information is given on station name changes, location changes, type of station, latitude and longitude, height of station and barometer height above mean sea level, and observations per day. For example, beginning in January 1965, most National Weather Service station data were key punched for the 3-hourly synoptic times only. Thus, there were eight observations per day in contrast to the previous key punching which was accomplished for all hourly observations. The observations per day column would have an "8" listed in the case of the 3-hourly synoptic observations, and a '24" for hourly observations. The instrumentation and history sheet also lists a history of the type of wind equipment and its height above ground. This equipment information is important for considering the representativeness of the wind for operational and planning considerations.

Chapter 2

WEATHER CONDITIONS AND ATMOSPHERIC PHENOMENA (PART A)

Part A of the RUSSWO consists of two sections: WEATHER CONDITIONS and ATMOSPHERIC PHENOMENA. The summaries given for weather conditions address the "hourly" and "all-hours" occurrences of the specified phenomena. The summaries for atmospheric phenomena give the percent of days per month and per year that the same specified phenomena occurred during the period of record used.

2.1 Percentage Frequency of Occurrence of Weather Conditions from Hourly Observations

Figures 2.1 and 2.2 illustrate respectively the "all-months, all-hours" and monthly "hourly" summaries of specified weather occurrences. The specified phenomena are defined on pages A-1 and A-2 of the RUSSWO. NOTE: The "Percent of Obs With Obst to Vision" excludes those cases where vision was obstructed by precipitation. Also the term "sleet" is obsolete; the current name of this phenomena is "ice pellets."

WEATHER CONDITIONS

STATION: 24[illegible] STATION NAME: [illegible] YEARS: [illegible] MONTH: ALL

MONTH	HOURS (LST)	THUNDER STORMS	RAIN AND/OR DRIZZLE	FREEZING RAIN AND/OR DRIZZLE	SNOW AND/OR SLEET	HAIL	% OF OBS WITH PRECIP	FOG	SMOKE AND/OR HAZE	BLOWING SNOW	DUST AND/OR SAND	% OF OBS WITH OBST TO VISION	TOTAL NO. OF OBS
[illegible]A	ALL		.5	.3	17.7		18.3	3.5	.1	2.4	.0	5.9	744[illegible]
FE[illegible]			1.[illegible]	.7	17.3		1[illegible].5	7.[illegible]	.2	1.[illegible]		9.7	6791
[illegible]A			1.6	.5	1[illegible].[illegible]		17.3	5.4	.1	3.[illegible]		[illegible].8	74[illegible]
[illegible]		.2	[illegible].6	.1	6.9	.	14.8	5.5	.2	1.[illegible]	.0	6.6	72[illegible]
A[illegible]		1.3	1.3		.2	.	1[illegible].4	2.4	.[illegible]	.[illegible]	.0	2.4	7439
[illegible]		2.[illegible]	7.4		.2		7.6	2.[illegible]	.0			2.0	7199
[illegible]JL		2.[illegible]	4.4			.1	4.4	.6	.0			.6	7439
[illegible]		1.9	3.7				3.7	1.1				1.1	7436
SEP		.7	5.2		.[illegible]	.	5.5	1.4			.0	1.4	7200
[illegible]CT		.1	4.[illegible]		[illegible].2		[illegible].[illegible]	2.[illegible]		.4	.0	2.5	7440
[illegible]			1.6	.4	12.3		13.9	5.5	.0	1.[illegible]		6.[illegible]	7193
[illegible]EC			.7	.1	1[illegible].2		1[illegible].9	5.[illegible]	.[illegible]	2.2		6.9	7436
TOTALS		.5	4.1	.2	7.7	.	11.7	3.5	.1	1.1	.0	4.6	87654

Figure 2.1. Percentage Frequency of Occurrence of Weather Conditions from Hourly Observations, 1967-1977, All-Months.

In Figures 2.1 and 2.2 the totals at the bottom of the summary are the mean annual or mean monthly percentage frequency of occurrence values. Since more than one weather condition may be reported in any given observation, say, rain and snow mixed, the "percentage of obs with precip" and the "percentage of obs with obst to vision" columns may contain values less than the sum of the values in columns to the left. Hence we find, for example, in Figure 2.1 that the "percentage of obs with precip" total is 11.7, yet the sum of the columns to the left is 12.8; and the sum of the values for fog (3.5), smoke and/or haze (0.1), blowing snow (1.1), and dust and/or sand (0.0) is 4.7 compared to a "percentage of obs with obst to vision" of 4.6. Conversely, not all of the potential contributing conditions need occur simultaneously for the "percentage of obs with..."

24006 ELLSWORTH AFB SD/RAPID CITY
STATION STATION NAME

PERCENTAGE FREQUENCY OF OCCURRENCE OF WEATHER CONDITIONS FROM HOURLY OBSERVATIONS

MONTH	HOURS (LST)	THUNDER STORMS	RAIN AND/OR DRIZZLE	FREEZING RAIN &/OR DRIZZLE	SNOW AND/OR SLEET	HAIL	FOG	[illegible]	SMOKE AND/OR HAZE	BLOWING SNOW	DUST AND/OR SAND	[illegible]	TOTAL %
JA	00-02	.	.5	.4	[illegible]		[illegible].9	2.		1.	.1	[illegible]	[illegible]
	03-05	.	.3	.5	[illegible]		24.[illegible]	[illegible]		1.[illegible]		[illegible]	[illegible]
	06-08	.	.2	.9	[illegible]		25.6	3.[illegible]		1.[illegible]		[illegible]	[illegible]
	09-11	.	.9		[illegible]		1[illegible].2	[illegible]	.1	2.[illegible]		[illegible]	[illegible]
	12-14	.	.8	.2	13.[illegible]		14.[illegible]	4.2	.[illegible]	[illegible]		[illegible]	[illegible]
	15-17	.	.4	.1	12.[illegible]		13.1	3.5		[illegible]		7.2	[illegible]3
	18-20	.	.5	.2	[illegible]		18.5	2.[illegible]		2.		5.[illegible]	[illegible]
	21-23	.	.5	.4	[illegible]		21.3	2.[illegible]		1.[illegible]		4.1	[illegible]
TOTALS			.5	.3	[illegible]		[illegible].2	3.[illegible]	.1	2.	.1	[illegible]	[illegible]

Figure 2.2. Percentage Frequency of Occurrence of Weather Conditions from Hourly Observations, 1968-1977, January.

columns to be incremented. [See USWB (1979) for a discussion of observing practices.]

As the name suggests, the percentage frequency of occurrence of weather conditions from hourly observations are derived from hourly data. Special (off-hour) observations, "Summary of the Day" data, etc., are not used. It is also important to realize that the mean number of days per month or per year cannot be cannot be determined from the WEATHER CONDITIONS SUMMARY. They must be found from the ATMOSPHERIC PHENOMENA SECTION of Part A.

Hourly data are given in terms of 3-hour time blocks. We assumed here that each hour of the interval has the same frequency of occurrence of the specified condition. If this were not so, there would be little reason for grouping these data. (Indeed, grouping of data does increase sample size and hence tends to ensure more stable means.) If values are required for discrete hours, plotting the percentage frequencies at the appropriate mid-hour of each 3-hour block, and then graphically interpolating (preferably with a smooth curve instead of a straight line) will give an adequately accurate estimate.

2.2 Exercises and Examples

Tables 2.1 and 2.2 contain a variety of questions along with procedures for determining answers from the WEATHER CONDITIONS "All-Months" summary (Figure 2.1, page 3) and the "January 3-hourly summary" (Figure 2.2, page 4) from the Ellsworth AFB RUSSWO. Many of the answers can be determined directly from the summaries and others require additional supporting information to determine an answer. The exercises are only intended to acquaint the user with the type of information that can be gleaned from these data summaries and therefore, are not intended to be comprehensive.

Table 2.1. Procedures for Determining Answers To Sample Questions from the WEATHER CONDITIONS - All-Months Summary (Figure 2.1, page 3).

To Find	Pertinent Row/Column	Answer
Mean percentage of time that fog occurs in February.	Feb/Fog	7.9
Mean percentage of time that thunderstorms occur in August.	Aug/Thunder-storms	1.9
Mean annual percentage of time that dust and/or sand occur.	Totals/Dust a/o Sand	0.0[1]
Mean percentage of time that hail is observed in June.	Jun/Hail	No Occur-rences in POR[2]
Mean percentage of time with precipitation in March.	Mar/% of Obs with precip	17.3[3]
Precipitation subcategories for March:		
Mean percentage of time with rain and/or drizzle.	Mar/Rain a/o drizzle	1.6
Mean percentage of time with freezing rain and/or drizzle.	Mar/Frz Rain a/o Drizzle	0.5
Mean percentage of time with snow and/or sleet.	Mar/Snow a/o sleet	15.8
Mean percentage of time with hail.	Mar/Hail	None
Mean percentage of time in October with obstructions to vision.	Oct/% of obs with obst to vision	2.5
Mean annual percentage of time with fog.	Totals/Fog	3.5

[1] It is seen from this exercise that dust and/or sand obstructions to visibility do occur during the year, but in such small numbers that the percentage becomes 0.0 after rounding off to the nearest tenth. The requester of this information should be apprised of this fact.

[2] Since no number is given, we know there were no occurrences of hail in June at Ellsworth AFB for the period 1967-1977.

[3] Observe that the total for the above listed subcategories equals 17.9 percent versus the 17.3 percent in the "Mar/percent of obs with precip" block. This stems from the reporting of multiple weather conditions occuring simultaneously.

Table 2.2. Procedures for Determining Answers To Sample Questions from the WEATHER CONDITIONS - January Summary (Figure 2.2, page 4).

To Find	Pertinent Row/Column	Answer
Mean percentage of time with blowing snow.	Totals/Blowing Snow	2.4[1]
Mean percentage of time with blowing snow, 0600-0800 LST.	06-08/Blowing Snow	1.5

Table 2.2 - Continued

To Find	Pertinent Row/Column	Answer
Mean percentage of time with fog, 1200-1400.	12-14/Fog	4.2 LST
Mean percentage of time with obstructions to vision 1500-1700 LST.	15-17/Obst to vision	7.2
Obstructions to Vision for January Subcategories:		
Mean percentage of time with fog.	15-17/Fog	3.5
Mean percentage of time with smoke and/or haze.	15-17/Smoke a/o Haze	None
Mean percentage of time with blowing snow.	15-17/Blowing Snow	4.0[2]
Mean percentage of time with rain and/or drizzle 2100-2300 LST.	21-23 Rain a/o Drizzle	0.5

[1] The answer on this exercise can also be obtained from the "ALL-MONTH" WEATHER CONDITIONS Summary (Figure 2.1, page 3 Row = blowing snow).

[2] The total percentage of the subcategories constituting meteorological elements which obstruct visibility is 7.5 percent whereas the 15-17/obst to vision block shows this percentage to be 7.2. This stems, once again, from the reporting of more than one weather condition, say, blowing snow and fog (an unlikely combination), on the same observation.

2.3 Atmospheric Phenomena from Daily Observations

This one page summary (Figure 2.3) lists the mean percentage of days having specific weather conditions as determined from all available weather data (i.e., hourly observations, special observations, summary of the day observations, etc.). One occurrence of a weather condition during a day, regardless of time or duration, is sufficient for that day to be considered a day with the specified atmospheric phenomenon. To illustrate this point, six thunderstorms in one day and one on another day are both counted a "day with thunderstorms." Since more than one type of precipitation or more than one type of obstruction to vision may occur on the same day, the sum of the values in the individual categories may differ from the totals in the "percent of obs with ..." columns.

To obtain the mean number of days per month that a given phenomenon occurs, multiply the figures in the appropriate percentage frequency block times the number of days in the given month and divide by 100. Use the same method to determine the number of days per year that the phenomenon occurs.

2.4 Exercises for the All-Months Atmospheric Phenomenon Summaries (Weather Conditions from Daily Observations)

Table 2.3 contains a variety of questions along with procedures for determining answers from the Atmospheric Phenomena All-Months Summary (Figure 2.3, from daily observations). Many of the answers can be determined directly from the summary while others require additional supporting information. The exercise is intended to acquaint the user with the type of information that can be gleaned from these data summaries and as such are not intended to be comprehensive. NOTE: The percentage of time a given phenomenon occurs cannot be determined from this summary. For such values, you must consult the "Percentage Frequency of Occurrence of Weather Conditions from Hourly Observations" discussed previously.

DATA PROCESSING BRANCH
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WEATHER CONDITIONS

ATMOSPHERIC PHENOMENA

24006	ELLSWORTH AFB SD/RAPID CITY	[illegible]-77	ALL
STATION	STATION NAME	YEARS	MONTH

PERCENTAGE OF DAYS WITH VARIOUS ATMOSPHERIC PHENOMENA
FROM DAILY OBSERVATIONS

MONTH	HOURS (LST)	THUNDER STORMS	RAIN AND OR DRIZZLE	FREEZING RAIN & OR DRIZZLE	SNOW AND OR SLEET	HAIL	% OF OBS WITH PRECIP	FOG	SMOKE AND OR HAZE	BLOWING SNOW	DUST AND OR SAND	% OF OBS WITH OBST TO VISION	TOTAL NO OF OBS
JAN	DAILY		7.8	1.6	49.1		51.6	18.0	.3	15.8	.1	29.4	935
FEB			11.5	3.1	52.3		55.3	26.4	.7	13.3		34.8	818
MAR		.3	15.3	2.3	47.7		53.9	23.9	1.0	11.9	.4	32.4	[illegible]
APR		4.3	37.1	1.9	28.1	.8	50.9	21.8	1.5	4.2		24.4	680
MAY		16.9	55.1	.2	3.9	4.1	55.3	16.1	.4	.6		14.9	[illegible]
JUN		32.7	54.1		.6	3.8	53.4	14.2	.2	.1		14.4	[illegible]
JUL		32.5	46.3			3.3	45.3	6.0				6.[illegible]	[illegible]
AUG		25.1	41.9			3.0	41.2	6.7	.2			6.3	[illegible]
SEP		8.8	33.8	.2	3.2	.6	33.7	9.0	.1	.1		9.1	[illegible]
OCT		.9	21.9	.9	10.6	.7	27.3	10.2	.2	1.1		10.[illegible]	[illegible]
NOV		.1	14.7	2.3	29.5	.2	36.6	15.7	.7	7.5		17.[illegible]	[illegible]
DEC		.1	9.7	2.2	40.3		43.9	18.9	.1	11.0		26.3	[illegible]
TOTALS		10.1	29.1	1.2	27.2	1.3	45.7	15.5	.4	5.5	.0	17.3	[illegible]

Figure 2.3. Percentage of Days with Various Atmospheric Phenomena from Daily Observations, 1948-1977, All-Months.

Table 2.3. Procedures for Determining Answers To Sample Questions from the ATMOSPHERIC PHENOMENON, All-Months, Daily Observations Summary (Figure 2.3, page 7).

To Find	Pertinent Row/Column	Answer
Mean number of days with thunderstorms in June, July, and August.	Jun,Jul,Aug/ Thunderstorms	10,10,8[1] (9.8,10.1, 7.8)
Mean number of days with fog in January, February, and March.	Jan,Feb,Mar/ Fog	5.6,7.4, 7.4
Mean annual number of days with fog.	Total/Fog	56.6
Mean annual number of days with smoke and/or haze in August.	Aug/Smoke a/o Haze	0.1[1]
Mean number of days with obstructions to vision in October.	Oct/Obst to Vision	3.4
Mean annual number of days with dust and/or sand which restricts the vision to less than 5/8 mile.[3]	Totals/Dust a/o Sand	0.0[2]
Mean number of days with precipitation in December; include subcategories.	Dec/% Obs with Precip	13.6
Mean number of days with rain and/or drizzle.	Dec/Rain a/o Drizzle	3.0

Table 2.3 - Continued

To Find	Pertinent Row/Column	Answer
Mean number of days with freezing rain and/or drizzle.	Dec/Frz Rain a/o Drizzle	0.7
Mean number of days with snow and/or sleet.	Dec/Snow a/o Sleet	12.7
Mean number of days with hail.	Dec/Hail	None

[1] Rounding to the nearest whole number is suggested when presenting data to a customer. All too often confusion arises over something happening on, say, 7.6 days per month. Persons not trained in statistics fail to realize that the mean of a sample need not be an element of the sample. For example, the mean of 1, 2, 4, and 5 is 3; yet, 3 is not an element of the sample. Caution must be used in rounding, however, lest we round to zero and mislead a customer into believing a phenomenon never occurs. Thus, the decision to round must be tailored to the particular case at hand.

[2] No value in a given block (row/column) means that the given phenomenon did not occur in the specified month (or at all if the totals row at the bottom is blank for the period of record considered). A value of "0.0" shows that the phenomenon has occurred, but that its frequency of occurrence (percent of days with) is less than 0.05 percent.

[3] In this summary, a day with dust and/or sand as an obstruction to vision occurs only when the visibility is reduced to less than 5/8 statute miles (sm), rather than the usual value of less than 7 sm.

Chapter 3

PRECIPITATION, SNOWFALL, AND SNOW DEPTH (PART B)

3.1 Part B Summary Description

Eight summaries derived from daily observations (all available data) are presented in Part B. Three summaries are for daily amounts of precipitation, snowfall, and snow depth. An additional three summaries are provided for extreme daily amounts by month and year for precipitaion, snowfall, and snow depth. The final set of two summaries provides total monthly amounts of precipitation and snowfall for each year-month and annual.

3.1.1 Percentage Frequency of Various Daily Amounts of Precipitation, Snowfall, and Snow Depth

Three summaries of daily percentage frequency of precipitation (Figure 3.1), snowfall (Figure 3.2), and snow depth (Figure 3.3) are presented. The "Daily Amounts" summaries are prepared for each month and an annual summary

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DAILY AMOUNTS

PERCENTAGE FREQUENCY OF PRECIPITATION
(FROM DAILY OBSERVATIONS)

24006 ELLSWORTH AFB SD/RAPID CITY 48-77
STATION STATION NAME YEARS

	AMOUNTS (INCHES)													PERCENT OF DAYS WITH MEASURABLE AMTS	TOTAL NO OF OBS	MONTHLY AMOUNTS (INCHES)		
PRECIP	NONE	TRACE	.01	.02-.05	.06-.10	.11-.25	.26-.50	.51-1.00	1.01-2.50	2.51-5.00	5.01-10.00	10.01-20.00	OVER 20.00			MEAN	GREATEST	LEAST
SNOWFALL	NONE	TRACE	0.1-0.4	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-6.4	6.5-10.4	10.5-15.4	15.5-25.4	25.5-50.4	OVER 50.4					
SNOW DEPTH	NONE	TRACE	1	2	3	4-6	7-12	13-24	25-36	37-48	49-60	61-120	OVER 120					
JAN	68.5	30.4	5.1	7.5	3.6	4.1	.9							21.1	899	.47	1.30	.01
FEB	44.3	31.9	3.8	9.5	4.0	4.5	1.3	.6						23.8	818	.65	2.19	TRACE
MAR	44.9	28.9	4.8	8.8	5.6	3.9	2.0	.8	.3					26.1	899	.97	2.78	.11
APR	47.4	23.3	3.1	7.6	3.6	6.5	4.7	2.6	1.3					29.3	898	2.13	5.59	.02
MAY	42.9	22.9	3.7	6.8	6.3	6.6	4.9	4.0	1.8	.1				34.2	930	2.93	9.81	.23
JUN	44.6	18.8	2.8	8.3	5.9	7.0	5.8	4.6	2.2	.1				36.7	900	3.23	7.74	.84
JUL	53.2	21.1	2.8	6.2	4.6	4.8	3.5	2.8	.6	.2				25.7	930	1.91	5.73	.04
AUG	57.3	18.9	3.1	6.0	3.0	5.1	3.7	2.4	.5					23.8	930	1.52	4.10	.09
SEP	64.9	16.6	2.2	5.2	2.6	3.9	2.1	2.0	.6					18.6	900	1.20	3.03	.01
OCT	71.0	15.4	1.9	3.5	2.6	2.3	2.0	1.2	.1					13.7	930	.77	1.92	.01
NOV	61.6	21.5	2.7	6.2	3.0	3.2	1.3	.4						16.9	899	.52	2.16	.08
DEC	54.7	26.5	3.3	7.6	3.7	3.7	.6							18.9	896	.42	1.10	TRACE
ANNUAL	52.9	23.0	3.3	6.9	4.0	4.6	2.7	1.8	.6	.0				24.1	10829	16.72		

Figure 3.1. Percentage Frequency of Precipitation from Daily Observations, 1948-1977, Daily Amounts.

(all years combined). These summaries include percent of days with measurable amounts; percent of days having none, a trace, and specified amounts. Also given are means, greatest, and least monthly amounts (the last three statistics are omitted from the snow depth summary because of their doubtful and limited value). A total count of valid observations is given for each month and annual summary. For stations for which a portion or all of the period may contain months with missing days, this will be noted on the summary pages. A percentage frequency value of "0.0" in these daily amount summaries indicates less than 0.05 percent which is usually only one occurrence.

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DAILY AMOUNTS

PERCENTAGE FREQUENCY OF SNOWFALL

(FROM DAILY OBSERVATIONS)

24006 ELLSWORTH AFB SD/RAPID CITY 48-77
STATION STATION NAME YEARS

			AMOUNTS INCHES											PERCENT OF DAYS WITH MEASURABLE AMTS	TOTAL NO OF OBS	MONTHLY AMOUNTS INCHES		
PRECIP	NONE	TRACE																
SNOWFALL	NONE	TRACE																
SNOW DEPTH	NONE	TRACE	1	2	3	4-6	7-12	13-24	25-36	37-48	49-60	61-72	OVER 72			MEAN	GREATEST	LEAST
JAN	50.9	28.1	10.7	6.8	2.1	.8	.3	.1	.1					2?.9	899	5.4	18.7	TRACE
FEB	47.6	29.3	10.8	6.8	2.9	1.6	.2	.5	.2					23.1	819	6.9	19.5	.5
MAR	51.5	25.4	9.7	8.0	2.2	1.2	.4	.6	.7	.3				23.1	899	9.4	28.7	.7
APR	71.3	15.9	4.8	3.0	2.0	1.1	.4	.9	.4		.1			12.8	898	7.0	42.8	.0
MAY	95.8	2.7	.3	.9	.2	.1	.1	.1						1.7	930	.7	7.1	.0
JUN	99.4	.2	.1	.1				.1						.3	900	.2	6.1	.0
JUL	100.0														930	.0	.0	.0
AUG	100.0														930	.0	.0	.0
SEP	96.9	2.6	.3	.2										.6	900	.1	1.6	.0
OCT	89.5	6.7	1.2	1.5	.5	.3		.2						3.9	929	1.5	8.2	.0
NOV	69.5	18.4	5.1	4.1	1.1	.7	.4	.4	.1	.1				12.1	899	4.5	16.0	.0
DEC	57.8	24.0	7.8	6.1	3.0	.9	.2	.1						18.1	899	5.0	11.0	TRACE
ANNUAL	77.5	12.8	4.2	3.1	1.2	.6	.2	.2	.1	.3	.0			9.7	10831	40.7		

Figure 3.2. Percentage Frequency of Snowfall from Daily Observations, 1948-1977, Daily Amounts.

3.1.2 Extreme Daily Amounts of Precipitation, Snowfall, and Snow Depth. Three summaries of extreme daily amounts of precipitation (Figure 3.4), snowfall (Figure 3.5), and snow depth (Figure 3.6) are presented which cover each month of each year. Data in these summaries consist of the various extremes and the means and standard deviations of the extremes for each month and for all months (annual summary along with the total valid observation count). Values for means and standard deviations exclude measurements from incomplete months. A prefix asterisk (*) is printed in any year-month block when the extreme value is based on an incomplete month (at least one day missing for the month). When a month has valid observations reported but no occurrences, zeros are entered in the summaries as follows

EXTREME DAILY PRECIPITATION "0.0" equals none for the month.

EXTREME DAILY SNOWFALL "0.00" equals none for the month (tenths).

EXTREME DAILY SNOW DEPTH "0" equals none for the month (whole inches).

3.1.3 Total Monthly Amounts of Precipitation and Snowfall. Two summaries (Figures 3.7 and 3.8) are provided for the total monthly amounts of precipitation and snowfall for each year-month and for all-months (annual summary). The summaries contain monthly and annual totals, means, standard deviations, and total number of valid observations for each month and annual (all months) values. Values for means and standard deviations do not include measurements from incomplete months. A prefix asterisk (*) is printed in each data block if one or more days are missing for the month. No occurrence for a month is indicated in the same manner as in paragraph 3.1.2. If a trace becomes the extreme or monthly total in any of the tables, it is printed as "TRACE."

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DAILY AMOUNTS

PERCENTAGE FREQUENCY OF SNOW DEPTH
(FROM DAILY OBSERVATIONS)

24006 ELLSWORTH AFB SD/RAPID CITY 48-77
STATION STATION NAME YEARS

SNOW DEPTH	NONE	TRACE	1	2	3	4-6	7-12	13-24	25-36	37-48	49-60	61-72	OVER 72	PERCENT OF DAYS WITH MEASURABLE AMTS	TOTAL NO OF OBS	MONTHLY AMOUNTS (INCHES) MEAN	GREATEST	LEAST
JAN	38.5	23.4	15.0	9.5	4.2	5.5	4.0							38.2	899			
FEB	42.2	16.1	11.6	10.4	6.0	8.4	4.5	.7						41.7	818			
MAR	52.4	16.0	10.7	6.9	4.7	5.3	3.1	.8						31.5	898			
APR	81.6	7.8	3.4	2.1	1.2	1.8	1.2	.8						10.6	899			
MAY	98.4	.5	.2	.3		.4	.1							1.1	930			
JUN	99.7	.1	.1			.1								.2	900			
JUL	100.0														930			
AUG	100.0														930			
SEP	99.7	.2		.1										.1	900			
OCT	94.7	2.4	1.3	.4	.5	.6								2.9	930			
NOV	72.0	12.5	5.8	3.4	2.0	3.3	1.0							15.6	899			
DEC	47.2	20.9	12.8	8.8	6.1	4.1	.1							31.9	899			
ANNUAL	77.2	8.3	5.1	3.5	2.1	2.5	1.2	.2						14.5	10832			

Figure 3.3. Percentage Frequency of Snow Depth from Daily Observations, 1948-1977, Daily Amounts.

3.2 General

3.2.1 Less Than Full-Time Stations. Precipitation, snowfall, and snow depth summaries may be prepared for stations operating for less than full time for portions or all of the period of record. This may include stations operating 5 or 6 days a week and those with only random days missing. An asterisk (*) in these data blocks will give an indication that a month is incomplete. Refer to the Station History Sheet (see Figure 4.1, page 23) at the front of the RUSSWO and the observation counts in each summary to evaluate the amounts of data missing.

3.2.2 Hail and Snow Occurrences. Hail was included in snowfall occurrences in the "Summary of the Day" observations prior to January 1956; therefore, care must be used when applying the statistics. Current procedures remove all hail occurrences in the pre-1956 data from the snowfall category and list them as hail in the Weather Occurrence Summary.

3.2.3 Snow Depth. Snow depth was recorded at various hours during the periods available from US-operated weather reporting stations. The hours used by each service for each period are as follows

Air Force Stations	US Navy and National Weather Service
Beginning through 1945 at 0800 LST	Beginning through Jun 52 at 0030 GMT
Jan 46 to May 57 at 1230 GMT	Jul 52 to May 57 at 1230 GMT
Jun 57 to present at 1200 GMT	Jun 57 to present at 1200 GMT

3.3 Exercises for the Precipitation, Snowfall, and Snow Depth Summaries

Tables 3.1-3.8 contain sample questions and their solutions illustrating the uses of the various summaries in Part B of the RUSSWO. Most of the answers can

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EXTREME VALUES

PRECIPITATI

FROM DAILY OBSERVATIONS

24004 ELLSWORTH AFB SD/RAPID CITY 48-77
STATION STATION NAME YEARS

24 HOUR AMOUNTS IN INCHES

MONTH / YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL MONTHS
48			*	.32	.70	.65	.34	1.09	.22	.92	.10	.14	
49	.12	.25	.10	1.05	1.03	1.33	.03	.39	.04	.53	.09*	.15	1.33
50	.50	.28	.61	1.40	1.00	.44	.39	.75	1.21	.37	.22	TRACE	1.4
51	.06	TRACE	.20	.10	.32	.97	.52	1.34	.99	.65	.09	.24	1.34
52	.01	.30	.36	.17	1.31	.85	.98	.74	.01	.01	.28	.03	1.31
53	.15	.64	.49	1.07	.42	1.90	.47	.82	.43	.04	.15	.07	1.90
54	.07	.17	1.09	.17	.99	1.35	.34	.66	.05	.47	.45	.11	1.35
55	.20	.99	.30	.61	1.59	.55	1.29	.49	.90	.15	.28	.22	1.59
56	.27	.11	.71	.56	.53	.54	.50	.73	1.34	.20	.40	.10	1.34
57	.16	.18	.19	.37	1.53	.52	.21	.54	.40	.33	.16	.03	1.53
58	.28	.14	.40	1.72	.41	1.65	.09	.43	.04	.33	.30	.22	1.75
59	.20	.24	.06	.73	1.07	.77	1.01	.79	1.03	.05	.63	.12	1.07
60	.14	.29	.27	.77	.70	1.35	.19	1.13	.57	.01	.19	.48	1.35
61	.11	.12	.39	.52	.33	.50	.52	.07	.27	.66	.34	.17	.66
62	.39	.31	.33	.26	2.09	.67	1.17	.40	.23	1.42	.04	.14	2.09
63	.22	.49	.95	1.22	1.14	1.55	.50	.32	.72	.30	.19	.04	1.55
64	.22	.33	.51	.65	.89	1.43	.22	1.01	.72	.49	.17	.27	1.43
65	.24	.09	.16	.49	3.09	.76	.79	.63	.59	.30	.09	.15	3.09
66	.06	.62	1.43*	1.40	.13	.43	1.68	.61	1.93	.82	.37	.10	1.93
67	.17	.07	.17	1.84	1.25	2.42	.84	.29	.57	.08	.20	.11	2.42
68	.10	.13	.04	.74	.36	2.30	1.25	.79	.41	.08	.16	.30	2.30
69	.03	.23	.14	.44	1.31	.85	3.23	.04	.23	.31	.11	.16	3.23
70	.31	.32	.38	1.66	.70	.80	.37	.19	.48	.22	.54	.22	1.80
71	.44	.25	.46	.83	1.22	.55	.31	.34	.95	.69	.23	.04	1.22
72	.11	.11	.19	.83	.73	2.30	2.66	.82	.10	.71	.11	.16	2.66
73	.03*	.05	1.26	.87	.71	.51	.60	.53	.59	.98	.25	.21	1.26
74	.06	.24	.19	.48	.70	.47	.69	1.03	.71	.79	.07	.05	1.03
75	.25	.09	.31	.88	.59	1.17	.91	.40	.03	.27	.13	.29	1.17
76	.26	.13	.10	.82	1.02	3.25	.50	.41	.16	.32*	.32	.15	3.25
77	.17	.09	.66	.94	1.19	.32	.72	.44	1.80	.96	.70		
MEAN	.184	.257	.429	.793	.968	1.153	.812	.606	.594	.453	.243	.155	1.895
S D	.122	.210	.359	.458	.593	.733	.695	.317	.506	.352	.168	.104	.646
TOTAL OBS	899	818	899	899	930	900	940	930	900	930	899	925	10923

NOTE * (BASED ON LESS THAN FULL MONTHS)

Figure 3.4. Extreme Values of Precipitation from Daily Observations, 1948-1977, 24-Hour Amounts in Inches.

be determined directly from the summaries. Others require ancillary data. These exercises are intended only to acquaint the user with the types of information that can be obtained from these data summaries. They are not intended to be comprehensive.

Table 3.1. Procedures for Determining Answers To Sample Questions from the Daily Amounts Precentage Frequency of Precipitation Summary (Figure 3.1, page 9).

To Find	Pertinent Row/Column	Answer
Mean percentage of days with a trace of precipitation in July.	Jul/Trace	21.1
Mean percentage of days with measurable precipitation in February.	Feb/% of Days	23.8
Mean percentage of days with precipitation (measurable and/or trace) in September.	Sep/Trace and % Days	35.2[1]
Mean percentage of days with 0.26 to 0.50 inches of precipitation in March.	Mar/0.26-0.50	2.0
Mean percentage of days with 1.01 to 2.50 inches of precipitation in November.	Nov/1.01-2.50	0

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EXTREME VALUES

SNOWFALL

FROM DAILY OBSERVATIONS

24 [illegible] ELLSWORTH AFB SD/RAPID CITY 48-77

STATION / STATION NAME / YEARS

24 HOUR AMOUNTS IN INCHES

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL MONTHS
48			*	.0	TRACE	.0	.0	.0	.0	TRACE	1.4	1.5	
49	3.0	2.5	1.0	TRACE	TRACE	.0	.0	.0	TRACE	1.0	.0	2.0	3.0
50	.9	1.7	6.7	4.6	3.5	.0	.0	.0	TRACE	3.0	3.9	TRACE	6.7
51	.6	.6	3.0	1.0	TRACE	*.0	.0	.0	TRACE	TRACE	.7	2.3	5.9
52	TRACE	3.0	3.6	.3	.0	.0	.0	.0	.0	TRACE	.4	.3	3.6
53	1.5	6.4	4.9	2.3	.9	.0	.0	.0	.0	.0	1.5	.7	6.4
54	.7	.7	10.9	TRACE	1.0	TRACE	.0	.0	.0	4.7	4.5	.5	10.9
55	2.0	9.7	3.0	6.1	.0	.0	.0	.0	.3	.5	2.8	2.2	9.7
56	2.7	1.1	7.1	[illegible].6	.6	.0	.0	.0	.0	.3	4.0	1.0	7.1
57	1.6	1.8	1.9	3.3	.0	.0	.0	.0	.3	TRACE	.4	.1	3.3
58	2.8	1.4	1.0	5.4	.0	.0	.0	.0	.0	.1	3.0	2.3	5.4
59	2.0	2.2	.6	8.0	TRACE	.0	.0	.0	TRACE	.5	7.1	1.2	8.0
60	1.4	2.9	1.0	5.4	.0	.0	.0	.0	TRACE	.1	1.6	5.8	5.8
61	1.1	1.2	3.6	2.2	TRACE	.0	.0	.0	.6	2.3	2.1	2.1	3.6
62	3.9	3.1	1.8	.5	.0	.0	.0	.0	TRACE	.0	.2	1.4	3.9
63	2.2	4.8	8.7	2.8	.0	.0	.0	.0	.0	TRACE	.4	.6	8.7
64	2.4	3.7	5.2	1.7	.0	.0	.0	.0	.0	.0	1.8	2.7	5.2
65	2.4	.9	1.6	5.4	4.5	.0	.0	.0	1.2	.0	.3	.1	5.4
66	.6	7.2	14.2*	8.6	.9	.0	.0	.0	.0*	.7	5.3	1.9	14.2
67	2.5	1.7	2.9	7.3	2.2	.0	.0	.0	TRACE	.0	2.0	1.9	7.3
68	3.4	2.2	.5	3.6	TRACE	.0	.0	.0	.0	.0	1.0	3.0	3.6
69	.4	2.9	1.8	1.8	TRACE	.8	.0	.0	.0	2.5	1.0	4.0	4.0
70	1.5	4.3	5.3	18.0	TRACE	.0	.0	.0	TRACE	2.3	3.0	2.8	18.0
71	6.9	2.8	5.7	5.4	.0	.0	.0	.0	TRACE	5.0	3.2	2.0	6.9
72	2.0	2.6	.3	1.3	.5	.0	.0	.0	TRACE	1.3	1.2	2.8	2.6
73	.8*	.8	14.0	2.5	.0	.0	.0	.0	.0	1.3	4.7	3.9	14.0
74	1.2	2.9	.5	4.2	.0	.0	.0	.0	TRACE	TRACE	.6	.6	4.2
75	4.1	2.1	3.2	1.9	.0	.0	.0	.0	.0	2.3	6.0	3.0	6.0
76	3.8	2.7	2.0	1.0	.0	.0	.0	.0	.0	.3*	3.0	3.0	3.6
77	1.0	.2	10.0	.2	.0	.0	.0	.0	.0	TRACE	12.0		
MEAN	2.05	2.83	4.34	3.64	.46	.22	.00	.00	.08	.95	2.62	1.92	6.22
S D	1.442	2.099	3.941	3.637	1.079	1.082	.000	.000	.248	1.429	2.617	1.351	3.247
TOTAL OBS	899	818	899	898	930	900	930	930	900	929	899	899	10831

NOTE * (BASED ON LESS THAN FULL MONTHS)

Figure 3.5. Extreme Values of Snowfall from Daily Observations, 1948-1977, 24-Hour Amounts in Inches.

Table 3.1 - Continued

To Find	Pertinent Row/Column	Answer
Mean annual percentage of days with a trace of precipitation.	Annual/Trace	23.0
Greatest amount of precipitation in May.	May/Greatest	9.81
Least amount of precipitation in August.	Aug/Least	0.09
Mean precipitation in December.	Dec/Mean	0.42
Mean annual precipitation.	Annual/Mean	16.72
The month with the greatest mean precipitation.	Jun/Mean	3.23
Mean annual number of days with measurable precipitation.	Annual/% of Days	88[2]
Mean annual number of days with a trace of precipitation.	Annual/Trace	84[3]
The month with the least precipitation on record.	Feb & Dec/ Least	Feb & Dec

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EXTREME VALUES

SNOW DEPTH

(FROM DAILY OBSERVATIONS)

24004 ELLSWORTH AFB SD/RAPID CITY 48-77

STATION STATION NAME YEARS

DAILY SNOW DEPTH IN INCHES

YEAR \ MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL MONTHS
48			*	0	0	0	0	0	0	0	1	3	
49	11	12	10	0	TRACE	0	0	0	TRACE	0	0	3	12
50	4	1	13	7	4	0	0	0	0	5	4	1	13
51	1	TRACE	6	2	0	4	0	0	0	TRACE	2	2	6
52	TRACE	4	5	TRACE	0		0	0	0	0	TRACE	1	5
53	1	15	11	2	TRACE	0	0	0	0	0	2	1	15
54	2	1	13	1	1	0	0	0	0	4	2	6	13
55	2	14	4	2	0	0	0	0	0	1	4	3	14
56	3	2	6	3	TRACE	0	0	0	0	TRACE	5	2	6
57	2	4	3	5	0	0	0	0	0	TRACE	TRACE	TRACE	5
58	3	3	2	5	0	0	0	0	0	0	2	3	5
59	2	4	1	11	0	0	0	0	0	TRACE	10	1	11
60	2	4	3	4	0	0	0	0	0	TRACE	2	3	4
61	2	2	2	3	0	0	0	0	TRACE	3	2	2	3
62	3	5	4	TRACE	0	0	0	0	0	0	TRACE	1	5
63	6	5	9	2	0	0	0	0	0	0	TRACE	1	9
64	2	5	5	2	0	0	0	0	0	0	2	8	8
65	4	1	2	4	6	0	0	0	2	0	0	0	6
66	3	7	6	10	0	0	0	0	0	1	4	5	10
67	2	3	3	0	10	0	0	0	0	0	2	4	10
68	5	3	0	3	0	0	0	0	0	1	1	4	5
69	1	4	2	3	0	1	0	0	0	3	2	4	4
70	7	4	7	23	0	0	0	0	0	3	3	5	23
71	9	13	6	4	0	0	0	0	0	6	3	3	13
72	2	4	2	TRACE	0	0	0	0	0	2	3	5	5
73	1*	2	15	2	0	0	0	0	0	TRACE	7	4	15
74	1	2	1	2	0	0	0	0	0	0	1	1	2
75	5	5	6	2	0	0	0	0	0	3	9	5	9
76	[illegible]	5	2	1	0	0	0	0	0	TRACE*	6	6	6
77	[illegible]	4*	15	15	0	0	0	0	0	1	12		
MEAN	3.5	4.7	5.9	4.1	.7	.2	.0	.0	.1	1.2	2.9	3.0	8.5
SD	2.772	3.551	4.105	5.252	2.184	1.104	.000	.000	.365	1.859	3.070	2.000	4.589
TOTAL OBS	899	814	898	899	930	900	930	930	900	930	899	899	10832

NOTE * (BASED ON LESS THAN FULL MONTHS)

Figure 3.6. Extreme Values of Snow Depth from Daily Observations, 1948-1977, Daily Snow Depth in Inches.

[1] The foregoing percentage was obtained by adding the percentage of days with a trace (16.6) and measured amounts (18.6). Compare this percentage with that of the All-Months summary of Part A, Atmospheric Phenomena from Daily Observation, Figure 2.3 (SEP/PRECIP block). The two values, 35.2 and 33.7, disagree because of the rounding that is used in the precipitation summary. The value in the Atmospheric Phenomena summary is slightly more accurate when all things correspond such as the number of observations and the period of record.

[2] Percent of days = 24.1, number of days per year = 365. Number of days per year with measurable precip = 0.241 x 365 = 88.0.

[3] 0.23 x 365 = 84.

Table 3.2. Procedures for Determining Answers To Sample Questions from the Daily Amounts Snowfall Summary (Figure 3.2, page 10).

To Find	Pertinent Row/Column	Answer
Mean number of days with measurable snowfall in December.	Dec/% of Days	5.6[1]
Mean percentage of days with snowfall (measured and trace) in March.	Mar/Trace and % of Days	48.5[2]
Mean percentage of days with snowfall (measured and trace) in February.	Feb/Trace and % of Days	52.4

DATA PROCESSING BRANCH
USAF/ETAC/OL A
AIR WEATHER SERVICE/MAC

EXTREME VALUES
MONTHLY PRECIPITATION
(FROM DAILY OBSERVATIONS)

24005 ELLSWORTH AFB SD/RAPID CITY 48-77
STATION STATION NAME YEARS

TOTAL MONTHLY PRECIPITATION IN INCHES

YEAR \ MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL MONTHS
48			*	.02	1.15	2.91	2.05	2.61	.51	1.20	.13	.14	
49	.48	.25	.32	2.42	1.61	2.08	.04	1.04	.07	1.15	.13*	.17	* 9.76
50	.63	.30	2.37	2.48	1.98	.84	1.22	2.32	2.29	.68	.33	TRACE	15.44
51	.06	TRACE	.70	.19	1.70	3.32	.92	4.10	2.72	1.30	.18	.80	15.99
52	.01	.78	.73	.21	6.01	2.51	1.63	1.60	.01	.01	.32	.03	13.85
53	.56	2.19	.59	3.33	2.12	5.14	.85	2.74	.65	.07	.52	.19	18.95
54	.17	.28	2.21	.18	2.48	3.11	.60	1.76	.08	1.01	.56	.25	12.69
55	.53	1.82	.82	1.16	2.29	2.35	2.55	1.28	2.26	.30	.50	.85	16.71
56	.59	.28	1.12	1.82	1.74	1.24	1.96	2.77	1.70	.23	.86	.34	14.65
57	.39	.41	.40	1.46	6.60	2.98	.71	1.38	.58	1.05	.32	.04	16.31
58	.28	.59	.89	5.45	1.02	6.24	3.95	.72	.06	.46	.80	.68	21.14
59	.62	.71	.21	1.50	2.54	1.86	1.08	1.02	2.59	.11	2.16	.37	14.77
60	.39	.99	.71	1.31	1.32	3.94	.33	2.45	.74	.01	.54	.89	13.62
61	.14	.29	.85	1.39	1.12	1.14	1.47	.10	.65	.84	.61	.60	9.20
62	1.30	1.13	.80	.56	9.81	3.05	3.02	.49	.31	1.82	.09	.24	22.63
63	1.12	1.31	1.12	3.69	2.37	3.84	1.27	.95	1.43	.62	.30	.19	18.21
64	.39	1.03	1.09	1.20	3.10	4.47	.63	1.56	.82	.49	.38	1.10	16.26
65	.77	.28	.49	1.51	7.56	3.23	2.55	2.45	1.83	.57	.27	.27	21.78
66	.27	.98	2.34*	3.04	.23	1.91	5.73	1.77	2.84	1.77	.94	.45	*22.27
67	.36	.25	.40	5.59	4.84	7.74	2.25	.76	1.96	.20	.23	.39	24.97
68	.25	.49	.11	1.79	1.25	6.80	2.08	2.26	.99	.08	.46	.70	17.25
69	.16	.85	.52	1.47	2.27	3.22	4.87	.09	.67	.67	.28	.38	15.45
70	.92	.50	1.32	4.50	2.53	2.64	.91	.37	1.52	.85	1.23	.55	17.84
71	1.05	.78	.86	3.23	4.11	1.87	.92	1.00	2.36	1.92	.62	.08	18.80
72	.31	.41	.44	2.87	3.61	6.21	4.52	1.52	.22	.84	.25	.41	21.61
73	.07*	.16	2.78	2.79	2.54	.92	1.98	1.21	1.74	1.32	.62	.41	*16.54
74	.10	.32	.43	1.47	2.56	1.09	1.49	2.29	.81	1.27	.08	.14	12.05
75	.78	.25	1.13	1.82	1.19	4.21	2.16	.79	.03	.45	.38	.79	13.98
76	.32	.68	.17	2.55	3.15	4.92	1.02	.68	.38	.38*	.74	.43	*15.42
77	.63	.18	2.18	1.71	3.16	1.16	2.41	1.40	3.03	1.41	.94		
MEAN	.470	.654	.969	2.130	2.932	3.232	1.906	1.516	1.195	.769	.518	.418	16.840
S.D	.333	.506	.727	1.419	2.128	1.836	1.371	.923	.964	.559	.425	.291	3.712
TOTAL OBS	899	819	899	899	930	900	930	930	900	930	899	896	10829

NOTE * (BASED ON LESS THAN FULL MONTHS)

Figure 3.7. Total Monthly Precipitation in Inches from Daily Observations, 1948-1977.

Table 3.2 - Continued

To Find	Pertinent Row/Column	Answer
Mean annual number of days with snowfall (measured and trace).	Annual/Trace and % of Days	82[3]
Mean annual number of days with snowfall 0.5 to 4.4 inches.	Annual/0.5-4.4	19[4]
Greatest amount of snowfall in March.	Mar/Greatest	28.7 in
Least amount of snowfall in November.	Nov/Least	0.0 in
Mean annual snowfall.	Annual/Mean	40.7 in
The month with the greatest snowfall on record.	Apr/Greatest	Apr
Mean amount of snowfall in May.	May/Mean	0.7 in

[1] 0.181 x 31 = 5.6. Consider rounding to 6.

[2] The answer of 48.5 percent can also be found from the Mar/None block by subtracting the value in the block (51.5) from 100.0.

[3] (1 - 0.775) x 365 = 82.1

DATA PROCESSING BRANCH
USAF/ETAC/OL A
AIR WEATHER SERVICE/MAC

EXTREME VALUES
MONTHLY SNOWFALL
FROM DAILY OBSERVATIONS

24006 (STATION) ELLSWORTH AFB SD/RAPID CITY (STATION NAME) 48-77 (YEARS)

TOTAL MONTHLY SNOWFALL IN INCHES

YEAR \ MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL MONTHS
48			*	.0	TRACE	.0	.0	.0	.0	TRACE	1.5	1.5	
49	12.1	2.5	2.4	TRACE	TRACE	.0	.0	.0	TRACE	1.[illegible]	.0	7.3	25.3
50	2.4	1.9	28.7	12.3	5.1	.0	.0	.0	TRACE	6.0	6.9	TRACE	63.3
51	.6	.7	6.6	1.4	TRACE	6.1	.0	.0	TRACE	TRACE	1.7	7.7	24.5
52	TRACE	7.5	5.8	.3	.0	.0	.0	.0	.0	TRACE	.4	.3	14.5
53	5.5	19.5	5.9	9.0	.9	.0	.0	.0	.0	.0	3.3	1.3	45.4
54	1.8	1.5	22.1	TRACE	1.9	TRACE	.0	.0	.0	6.5	5.6	1.0	40.4
55	5.3	18.0	8.2	6.6	.0	.0	.0	.0	.3	.7	4.5	8.5	52.1
56	4.5	2.8	11.2	13.8	.6	.0	.0	.0	.0	.2	8.6	3.2	45.0
57	3.8	4.1	4.0	11.9	.0	.0	.0	.0	.3	TRACE	1.2	.1	25.4
58	3.0	4.7	4.6	16.1	.0	.0	.0	.0	.0	.1	4.4	6.6	39.5
59	4.7	6.9	2.1	13.3	TRACE	.0	.0	.0	TRACE	.5	16.0	3.4	46.9
60	3.9	9.9	4.4	6.6	.0	.0	.0	.0	TRACE	.1	4.6	10.6	40.1
61	1.4	2.1	7.0	4.0	TRACE	.0	.0	.0	.6	2.7	3.7	6.1	27.0
62	12.3	7.6	6.1	.6	.0	.0	.0	.0	TRACE	.0	.2	2.3	29.1
63	11.2	10.9	10.5	4.7	.0	.0	.0	.0	.0	TRACE	.4	2.1	39.0
64	4.3	10.0	10.4	3.5	.0	.0	.0	.0	.0	.0	3.6	11.0	42.0
65	5.5	2.7	4.9	7.8	7.1	.0	.0	.0	1.6	.0	.6	.1	[illegible]
66	2.7	10.8	24.1*	12.1	.5	.0	.0	.0	.0*	.7	8.2	5.5	* 45.0
67	6.5	7.0	7.4	7.3	4.3	.0	.0	.0	TRACE	.0	4.0	10.7	47.2
68	8.5	7.2	1.3	9.0	TRACE	.0	.0	.0	.0	.0	1.1	9.9	37.[illegible]
69	1.9	10.2	5.6	2.0	TRACE	.4	.0	.0	.0	2.5	2.7	6.4	33.1
70	5.9	6.0	15.6	42.8	TRACE	.0	.0	.0	TRACE	5.0	4.3	9.1	89.5
71	18.7	9.1	13.5	7.0	.0	.0	.0	.0	TRACE	8.2	8.8	3.1	68.4
72	5.6	10.4	.7	1.6	.5	.0	.0	.0	TRACE	2.4	3.2	7.5	31.9
73	1.8*	2.3	19.2	3.5	.0	.0	.0	.0	.0	2.3	11.2	6.3	* 46.6
74	2.4	4.6	1.2	6.1	.0	.0	.0	.0	TRACE	TRACE	.6	2.2	17.1
75	13.3	7.2	16.4	2.7	.0	.0	.0	.0	.0	5.0	7.6	4.0	56.2
76	4.3	5.1	4.2	1.0	.0	.0	.0	.0	.0	.3*	4.0	6.6	* 26.5
77	2.1	.5	19.6	.3	.0	.0	.0	.0	.0	TRACE	12.6		
MEAN	5.38	6.87	9.44	7.01	.70	.23	.00	.00	.09	1.53	4.53	5.[illegible]1	4[illegible].5[illegible]
S D	4.365	4.677	7.475	8.413	1.718	1.118	.000	.000	.313	2.410	4.047	3.561	16.706
TOTAL OBS	899	818	899	898	930	900	930	930	900	929	899	899	10631

NOTE * (BASED ON LESS THAN FULL MONTHS)

Figure 3.8. Total Monthly Snowfall in Inches from Daily Observations, 1948-1977.

[4] Add the percentages for the snowfall increments 0.5-1.4 (3.1), 1.5-2.4 (1.2), 2.5-3.4 (0.6), and 3.5-4.4 (0.2); divide this percentage by 100, then multiply by the number of days in the year (365): (5.1/100 x 365 = 18.6.)

Table 3.3. Procedures for Determining Answers To Sample Questions from the Daily Amounts Snow Depth Summary (Figure 3.3, page 11).

To Find	Pertinent Row/Column	Answer
Mean percentage of days with measurable snow depth in January.	Jan/% of Days	38.2
Mean number of days with measurable snow depth in February.	Feb/% of Days	11.7
Mean percentage of days with snow depth (trace and measured) in March.	Mar/Trace and % of Days	47.5[1]
Mean number of days with snow depth (trace and measured) in December.	Dec/Trace and No. of Days	16.4
Mean annual number of days with snow depth (trace and measured).	Annual/Trace and % of Days	83.2
Mean annual number of days with a trace of snow depth.	Annual/Trace	30.3

Table 3.3 - Continued

To Find	Pertinent Row/Column	Answer
Mean annual number of days with snow depth 1 to 3 inches.	Annual/1-3	39[2]
Mean annual number of days with snow depth 4 to 6 inches.	Annual/4-6	9
Mean number of days in January with snow depth 3 to 6 inches.	Jan/3-6	3
Mean number of days with a trace of snow depth for January, February, and March.	Jan,Feb,Mar/ Trace	7+4+5=16[3] (7.3+4.5 +5.0=17.0)
Mean number of days with snow depth (trace and measured) for January, February, and March.	Jan,Feb,Mar/ Trace and % of Days	19.1+16.2 +14.8=50
Mean percentage of days with snow depth 7 to 12 inches in October.	Oct/% of Days	None[4]

[1] A trace of snow depth indicates that the snow on the ground is visible but not measurable.

[2] To obtain the answer, add the individual percentages for 1 (5.1), 2 (3.5), and 3 (2.1) inches, divide this percentage by 100, multiply it by the number of days in the year (365.25), and round.

[3] Note the different answers obtained with and without rounding (16 vs 17 days per year).

[4] The lack of an entry indicates that no occurrences of snow depth 7 to 12 inches were observed from 1948 to 1977.

Table 3.4. Procedures for Determining Answers To Sample Questions from the Extreme Values Precipitation Summary (Figure 3.4, page 12).

To Find	Pertintent Row/Column	Answer
Month with the greatest 24-hour precipitation in 1949.	49/Jun	Jun
Month with the smallest 24-hour precipitation in 1976.	76/Mar	Mar
Extreme 24-hour precipitation in 1969.	69/Jul or All-Months	3.23 in
Extreme 24-hours precipitation in October 1973.	73/Oct	0.98 in
Extreme 24-hour precipitation in December (all years).	60/Dec	0.48 in
Extreme 24-hour precipitation in May (all years).	65/May	3.09 in
Mean of extreme 24-hour precipitation in April.	Mean /Apr	0.793 in
Standard deviation[1] of the extreme 24-hour precipitation in April.	S.D./Apr	0.458

Table 3.4 - Continued

To Find	Pertinent Row/Column	Answer
Mean annual extreme 24-hour precipitation.	Mean/All-Months	1.695
Greatest monthly extreme 24-hour precipitation.	76/Jun or All Months	3.25
Highest monthly standard deviation of the extreme 24-hour precipitation.	S.D./Jun	0.733

[1] The standard deviation is a measure of the deviation of individual numbers of a given distribution from the mean of the distribution. For a normal or Gaussian distribution, it happens that 68 percent of the numbers are included between the mean minus one standard deviation and mean plus one standard deviation. Extreme values cannot usually be described by a normal distribution, and as a result the aforementioned percentage does not apply, but the standard deviation is still a useful tool in working with extreme values. For additional background material, refer to Gringorten (1960).

Table 3.5. Procedures for Determining Answers To Sample Questions from the Extreme Values Snowfall Summary (Figure 3.5, page 13).

To Find	Pertinent Row/Column	Answer
Extreme 24-hour snowfall in January in 1949.	49/Jan	3.0 in
Extreme 24-hour snowfall in November 1976.	76/Nov	3.0 in[1]
Extreme 24-hour snowfall in May 1966.	66/May	0.5 in
Extreme 24-hour snowfall in January (all years).	71/Jan	6.9 in
Extreme 24-hour snowfall in November (all years).	77/Nov	12.0 in
Month with the greatest 24-hour snowfall in 1957.	57/Apr	Apr
Month with the greatest 24-hour snowfall on record.	70/Apr	Apr
Standard deviation[2] of the extreme 24-hour snowfall in February.	S.D./Feb	2.099 in
Standard deviation of the extreme 24-hour snowfall in November.	S.D./Nov	2.617 in
Mean annual extreme 24-hour snowfall.	Mean/All-Months	6.22 in
Highest monthly mean of the extreme 24-hour snowfall.	Mean/Mar	4.34 in
Highest monthly standard deviation of the extreme 24-hour snowfall.	S.D./Mar	3.941 in
Mean extreme 24-hour snowfall for the period January, February, and March to two significant digits.	See Footnote 3	3.07 in

[1] Based on less than a full month of data.

[2] See Footnote 1, Table 3.4.

[3] The mean can be approximated by adding the mean monthly amounts for January, February, and March (9.22) and dividing by 3 or determined properly by totaling the reported values for all three months (265.5) and dividing by 82 (total number of months for which observations are reported). NOTE: The mean of several mean values will equal the mean of all individual elements only if all of the samples are of the same size. An example of the mean of means not equalling the population mean is

Sample 1	Sample 2	Population
2,4,6,8,10	12,14	2,4,6,8,10,12,14
Mean 1 = 6	Mean 2 = 13	Mean = 8

Mean of sample means = (6 + 13)/2 = 9.5

In our particular case the true mean is 3.05 as contrasted with 3.07 as the mean of the means approximation. If February had 31 days so that all three columns had the same total number of observations (899), the mean of the means would equal the mean of the tabulated values.

Table 3.6. Procedures for Determining Answers To Sample Questions from the Extreme Values Snow Depth Summary (Figure 3.6, page 14).

To Find	Pertinent Row/Column	Answer
Month with the greatest extreme daily snow depth in 1951.	51/Mar	Mar
Value of the greatest extreme daily snow depth in 1959.	59/Apr	11 in
Extreme daily snow depth in February 1973.	73/Feb	2 in[1]
Extreme daily snow depth in April 1968.	68/Apr	3 in
Extreme daily snow depth in February (all years).	53/Feb	15 in
Greatest extreme daily snow depth recorded from 1949 to 1976.	70/Apr or All-Months	23 in
Mean extreme daily snow depth in February.	Mean/Feb	4.7 in
Standard deviation[2] of the extreme daily snow depth in March.	S.D./Mar	4.105 in
Mean annual extreme daily snow depth.	Mean/All-Months	8.5 in
Highest monthly mean of the extreme daily snow depth.	Mean/Mar	5.5 in

[1] The asterisk (*) in the February 1973 entry indicates that at least one of the 28 potential snow depth observations for the month is missing. We do not know how many daily observations were consulted to obtain the 2-inch maximum; it could have been 27 or it could have been just one. In older RUSSWOs, those produced before 24 March 1974, a blank was shown instead of results based on an incomplete month of data. In such cases some estimate of extreme snow depth may be obtained by checking the daily amounts summary for extreme snowfall (see Figure 3.5) to see if any snowfall occurred, and checking the extreme temperature values (Figure 6.6) to see if the snow might have lasted on the ground. Appropriate subjective

and objective adjustments should be used to allow for snow compaction and settling, melting, and sublimation, etc.

[2] See Footnote 1, Table 3.4., page 17.

Table 3.7. Procedures for Determing Answers To Sample Questions from the Monthly Precipitation Summary (Figure 3.7, page 15).

To Find	Pertinent Row/Column	Answer
Month with the greatest total monthly precipitation in 1949.	49/Apr	Apr
Total monthly precipitation in July 1960.	60/Jul	0.33 in
Total annual precipitation in 1976.	76/All-Months	15.42 in[1]
Year with the greatest monthly precipitation in December.	64/Dec	64
Year with the greatest monthly precipitaion in June.	67/Jun	67
Mean of total monthly precipitation in April.	Mean/Apr	2.130 in
Standard deviation[2] of the total monthly precipitation in April.	S.D./Apr	1.419 in
Mean annual total monthly precipitation.	Mean/All-Months	16.840 in
Greatest total monthly precipitation (all years).	62/May	9.81 in
Highest monthly mean of precipitation.	Mean/Jun	3.232 in
Highest monthly standard deviation of precipitation	S.D./May	2.128 in
Greatest annual precipitation amount.	67/All-Months	24.97

[1] This total is based on incomplete data. Specifically, at least one precipitation report is missing from November 1976. We have no way of knowing what this missing value (or values) was.

[2] See Footnote 1, Table 3.4.

Table 3.8. Procedures for Determining Answers To Sample Questions from the Monthly Snowfall Summary (Figure 3.8, page 16).

To Find	Pertinent Row/Column	Answer
Month with the greatest total monthly snowfall in 1949.	49/Jan	Jan
Total monthly snowfall in July 1970.	70/Jul	None[1]
Total annual snowfall in 1976.	76/All-Months	26.5[2] in
Year with the greatest monthly snowfall in December.	64/Dec	1964

Table 3.8 - Continued

To Find	Pertinent Row/Column	Answer
Year with the greatest monthly snowfall.	70/Apr	1970
Mean monthly snowfall in April.	Mean/Apr	7.01 in
Standard deviation[3] of the total monthly snowfall in April.	S.D./Apr	8.413 in
Mean annual snowfall.	Mean/All-Months	40.50 in
Greatest monthly total snowfall.	70/Apr	42.8 in
Highest monthly mean snowfall.	Mean/Mar	9.44 in
Largest annual snowfall.	70/All-Months	89.5 in
Highest monthly standard deviation of snowfall.	S.D./Apr	8.413 in

[1] When a month has valid observations but no occurrences, a 0.0 is entered in the table.

[2] An asterisk (*) is indicated with this value because the month of November had at least one day missing. Whether snow occurred on the missing day is not known.

[3] See Footnote 1, Table 3.4., page 17.

Chapter 4

SURFACE WINDS (PART C)

4.1 General

Part C of the RUSSWO contains four groupings of summaries. The first is a listing of peak wind gusts for each year-month along with monthly and annual means and standard deviations. The second, based on hourly observations, contains bivariate percentage frequency distributions by month and year of the wind direction and speed. The third gives similar data by month for eight 3-hourly periods. The fourth has a bivariate percentage frequency distribution (annual summary only) of wind direction by speed groups based on wind observations taken during "INSTRUMENT CONDITIONS" (see paragraph 4.3 below).

Wind speeds are given in knots and the speed groupings are according to the Beaufort Scale (e.g., Beaufort Force 1 = 1-3 kt; Beaufort Force 4 - 11-16 kt; etc.). Wind directions are given according to the 16 points of the compass (N, NNE, NE, etc., or in tens of degrees (32 = 320° = 315-325, etc.). Directions are with respect to true north.

The Surface Wind Equipment information portion of the Station Location and Instrumentation History sheet (Figure 4.1) should be studied before using the various wind summaries. Usually, given an adequately long period of record, the locations of the wind sensors and the types of equipment used have changed during the period. Keep this information in mind when applying these data to specific requirements since the summaries are a composite of information covering the period of record from a possible variety of equipment and anemometer heights and locations. The various wind data and statistics are not normalized to some standard height.

4.2 Extreme Values-Surface Winds

Extreme wind data are provided for each month of each year of the period of record given that sufficient data are available (Figure 4.2). These wind values are derived from daily observations. According to Federal Meteorological Handbook No. 1 (FMH-1), "peak gust data are recorded only at stations with continuous instantaneous wind speed recorders." Thus, some stations may not have this summary or may have an incomplete one.

Before July 1968, the direction of the daily peak gust in knots is given according to the 16 points of the compass. Subsequent to that date, directions are given in tens of degrees. An asterisk (*) is printed in the data block if less than 90 percent (three or more missing observations) of the peak gust data is available for the month. A dollar sign ($) indicates that the peak gust was in excess of 100 knots and thus that 100 must be added to the two-digit value given in the table.

An all-months value is presented when every month of the year has at least some valid observations. Means and standard deviations are computed when four or more values are present in the given column. However, calculations of the mean and standard deviation do not include data for incomplete months. For each month and for the all-months column, a total count of all valid observations is given.

4.3 Bivariate Percentage Frequency Tabulations

The annual, monthly, and hourly tabular wind roses (bivariate percentage frequency tabulations) (Figures 4.3-4.6) are derived from hourly observations. The percentage frequencies are tabulated according to wind direction (16 points of the compass) and wind speed (Beaufort Scale speed intervals). Also given are values for variable winds and for calm winds, along with the mean wind speed for each direction. When a percentage frequency of "0.0" is given, it means that the appropriate wind did occur during the period of record, but that it was such a rare event that, after rounding, the percentage frequency was less than 0.05. Thus, it is possible to sum the zeros in a given speed interval column and get a total of 0.1 or 0.2 or so up to a maximum of 0.6.

STATION NO. ON SUMMARY	STATION NAME	LATITUDE	LONGITUDE	FIELD ELEV (FT)	CALL SIGN	WMO NUMBER
24006	ELLSWORTH AFB/RAPID CITY	[illegible] 44 09	W 103 06	3276 FT	RCA	

STATION LOCATION AND INSTRUMENTATION HISTORY

NUMBER OF LOCATION	GEOGRAPHICAL LOCATION & NAME	TYPE OF STATION	AT THIS LOCATION FROM	AT THIS LOCATION TO	LATITUDE	LONGITUDE	ELEVATION ABOVE MSL FIELD (FT)	ELEVATION ABOVE MSL HT BARO	OBS PER DAY
1	Rapid City AFB SD	AFB	[illegible]	[illegible]	N [illegible] 06	W 103 05	3196	[illegible]	24
2	Same	Same	[illegible]	[illegible]	N 44 09	W 103 06	3246	3215	24
3	Ellsworth AFB SD	Same	Apr [illegible]	May 55	Same	Same	Same	Same	24
4	Same	Same	[illegible]	Feb 58	Same	Same	Same	Same	24
5	Same	Same	[illegible]	Dec 70	Same	Same	3276	Same	24
6	Same	Same	[illegible] 71	Dec 78	Same	Same	Same	Same	24

NUMBER OF LOCATION	DATE OF CHANGE	SURFACE WIND EQUIPMENT INFORMATION: LOCATION	TYPE OF TRANSMITTER	TYPE OF RECORDER	HT ABOVE GROUND	REMARKS, ADDITIONAL EQUIPMENT OR REASON FOR CHANGE
1	Apr 48	Not available.	anemometer	N/A	N/A	
2	Jun 50	Located on control tower.	Selsyn	MI-14-	100 ft	
3	Jun 55	Same	GMQ-11	RO-[illegible]	107 ft	
4	Apr 56	Located approximately 1200 ft SW of weather stn near center of NW-SE runway.	Same	RO-2A	13 ft	
5	May [illegible]	1. Located 800 ft from centerline and 1700 ft from end of rnwy 30. 2. Located 730 ft from centerline and 500 ft from end of rnwy 12.	GMQ-20	Same	20 ft 28 ft	
6	May 69	1. Same 2. Same	Same Same	RO-362	Same Same	
7	Jan 71	1. Located 887 ft from centerline and 1886 ft from end of rnwy 30. 2. Located 730 ft from centerline and 892 ft from end of rnwy 12.	Same Same	Same	Same Same	
8	Nov 77	1. Same 2. Same	Same Same	Same	Same Same	

Figure 4.1. Station Location and Instrumentation History, April 1948 to December 1978.

The tabular wind roses are grouped first by month- (all hours) and annual- (all hours) then by month according to 3-hour time blocks, and finally an annual all-hour summary is given for so-called "instrument" conditions. Instrument weather, for RUSSWO purposes, is defined as ceiling 200-1400 feet with visibility 0.5 statute mile (sm) or greater and/or visibility 0.5-2.5 sm with ceiling of 200 feet or more. Thus, specifically excluded on the low end are conditions below 200 feet ceiling and/or 0.5 sm visibility.

4.4 Exercises for the Extreme Values Wind, All-Weather Surface Winds Summary

Tables 4.1 through 4.5 contain sample questions and their solutions illustrating the uses of the various summaries in Part C of the RUSSWO. Most of the answers can be determined directly from the summaries. These excercises are intended only to acquaint the user with the types of information that can be obtained from these data summaries. They are not intended to be comprehensive.

Table 4.1. Procedures for Determining Answers To Sample Questions from the Extreme Values Surface Wind Summary (Figure 4.2, page 25).

To Find	Pertinent Row/Column	Answer
Month and year with the greatest recorded extreme daily peak gust.	64/Sep	Sep 1964[1]
Direction and magnitude of the greatest extreme daily peak gust.	64/Sep	NW 76
Extreme daily peak gust for 1953.	53/All-Months	WNW 70

Table 4.1 - Continued

To Find	Pertinent Row/Column	Answer
Month with extreme daily peak gust for 1959.	59/Jul	Jul (NE 70)
Extreme daily peak gust for May 1972.	72/May	30/56
Extreme daily peak gust for July (all years).	59/Jul	NE/70
Standard deviation of the extreme daily peak gust in August.	S.D./Aug	8.318[2]
Mean extreme daily peak gust in July.	Mean/Jul	48.9
Mean annual extreme daily peak gust.	Mean/All-Months	62.6[3]

[1] From the "Station Location and Instrument History Sheet" (Figure 4.1), it is seen that several changes were made in the location of the wind equipment. For example during May 1964, the locations of the wind equipment for runways 30 and 12 were changed to the respective heights of 20 and 28 feet from 13 feet. As a direct result of the changes in both the horizontal and vertical position of the wind measuring devices, the figures in this summary are not necessarily representative. They are, however, all that are available unless a correction factor can be deduced which reduces the wind data to the standard anemometer height of 13 feet as used by the USAF since 1978. For stations not under USAF purview, different standards are followed. Since 1974 the National Weather Service has followed World Meteorological Organization Technical Regulation Procedures (1971) and uses 10 meters as the standard height unless local restrictions preclude installation of the 10 meter tower, in which case the installation will be at 20 feet. The Federal Aviation Administration (1979) also follows World Meteorological Organization procedures.

[2] See Footnote 1, Table 3.4., page 17.

[3] The answer is based on only those 25 values listed in the ALL-MONTHS column and is not completely reliable in that 4 values are missing for years with less than the full 12 months record.

Table 4.2. Procedures for Determining Answers to Sample Questions for the All-Months, All-Hours, All-Weather Surface Winds Summary (Figure 4.3, page 26).

To Find	Pertinent Row/Column	Answer
Mean annual percentage of time that winds are calm.	Calm/%	13.8
Annual prevailing wind direction.	NNW/%	NNW[1]
Mean speed of the annual prevailing wind direction.	NNW/Mean Wind Speed	14.2 kt
Mean annual percentage of time that wind speeds greater than 47 knots occur from the NNW.	NNW/48-55, 56	0.0[2]
Mean annual wind speed.	Bottom Row/ Wind Speed	8.2 kt
Mean annual wind speed, excluding calms.	All Directions/% Mean Wind Speed	9.5[3]

DATA PROCESSING [illegible]
USAF/ETAC/OL A
AIR WEATHER SERVICE [illegible]

EXTREME VALUES

SURFACE [illegible]

FROM [illegible] OBSERVATIONS

24[illegible] STATION — ELLSWORTH [illegible] RAPID CITY — STATION NAME — 49-77 YEARS

[illegible] STS I[illegible] KNOTS

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		ALL MONTHS
49				[illegible]*37		[illegible]S	46[illegible]	[illegible]5		49[illegible]	4[illegible]	[illegible]*54[illegible]W	54[illegible]	[illegible]	
50	[illegible]W	62[illegible]	57[illegible]	*7[illegible]	54[illegible]	[illegible]			[illegible]*4[illegible]	39[illegible]	55[illegible]N	*49			
51											*5[illegible]W	65[illegible]	*55		
52	[illegible]*3[illegible]E	*38[illegible]W	*59[illegible]	*72[illegible]	*49[illegible]	*6[illegible]	*52[illegible]S	*59SS	*45[illegible]	45[illegible]W	545	5[illegible]			*7[illegible]
53	[illegible]	54[illegible]	44[illegible]	67[illegible]	57[illegible]	47[illegible]	7[illegible]S	47SS[illegible]	44[illegible]	53	44[illegible]N	54[illegible]	54		7[illegible]
54	[illegible]NW	52[illegible]	60NN[illegible]	59	5[illegible]	49[illegible]	45S	59[illegible]	49[illegible]N	52[illegible]	43NN[illegible]	60[illegible]	57		[illegible]
55	[illegible]	6[illegible]	58[illegible]	59[illegible]	49[illegible]	59[illegible]	4[illegible]S	*43[illegible]S	59SSE	48[illegible]	4[illegible]WN[illegible]	50S	57		[illegible]
56	[illegible]*5[illegible]	41[illegible]	6[illegible]	45[illegible]	37S	45[illegible]	47SS[illegible]	63[illegible]	42[illegible]	45[illegible]	53[illegible]	5[illegible]		SS	[illegible]
57	N[illegible]	51	47[illegible]W	44[illegible]	37[illegible]	45N	51[illegible]	40[illegible]	41[illegible]	35[illegible]	3[illegible]	38[illegible]	49		[illegible]
58	[illegible]	34[illegible]	44[illegible]	32[illegible]	38[illegible]	5[illegible]	35[illegible]	4[illegible]	35[illegible]	4[illegible]	4[illegible]	61[illegible]	45		[illegible]
59	[illegible]	46[illegible]	43[illegible]W	45[illegible]	45[illegible]	43[illegible]	4[illegible]E	70[illegible]	42[illegible]	49[illegible]	52[illegible]	59[illegible]	57		7[illegible]
60	[illegible]	46[illegible]	37[illegible]W	51S	5[illegible]	41[illegible]	5[illegible]SS[illegible]	36SS[illegible]	53[illegible]	36	47[illegible]W	49[illegible]	46	S[illegible]	[illegible]
61	[illegible]W	43[illegible]	46NN[illegible]	38[illegible]	49[illegible]	37[illegible]	3[illegible]	47[illegible]	33[illegible]	37[illegible]	*39[illegible]	*49[illegible]	5[illegible]		5[illegible]
62	[illegible]W	47[illegible]	47[illegible]W	44[illegible]	54[illegible]	39[illegible]	55[illegible]	31[illegible]	54[illegible]	46[illegible]	49[illegible]W	45[illegible]	5[illegible]		[illegible]
63	[illegible]W	52N[illegible]	61NN[illegible]	48[illegible]SW	59[illegible]	52S	6[illegible]	61S	37[illegible]	34[illegible]	35[illegible]	44[illegible]	52	S[illegible]	[illegible]
64	[illegible]	44N[illegible]	46[illegible]W	53[illegible]	69[illegible]	43[illegible]	52SE	53[illegible]	6[illegible]N[illegible]	76[illegible]	6[illegible]NN[illegible]	58[illegible]	52		7[illegible]
65	[illegible]W	69N[illegible]	53[illegible]W	45[illegible]	44[illegible]	51SE	47[illegible]	58[illegible]	39[illegible]N[illegible]	4[illegible]	53[illegible]	*45[illegible]	4[illegible]		[illegible]
66	[illegible]	58N[illegible]	34[illegible]W	66[illegible]	52S[illegible]	51W	4[illegible]	53[illegible]	45[illegible]	3[illegible]	54[illegible]	45[illegible]	51		[illegible]
67	[illegible]	65NW	54NN[illegible]	41[illegible]	72[illegible]	62N	4[illegible]	39[illegible]	36[illegible]	47[illegible]	54[illegible]W	46N	54		72[illegible]
68	[illegible]W	42[illegible]	41[illegible]W	45[illegible]	46SSE	48N	[illegible]32/	4127/	4234/	4[illegible]32/	5[illegible]32/	4434/	5[illegible]	34/	[illegible]
69	29/	5929/	3729/	5332/	5334/	5432/	[illegible]28/	6033/	4533/	44[illegible]3/	5[illegible]31/	5031/	54	2[illegible]/	[illegible]
70	32/	5131/	5[illegible]35/	5033/	4631/	503[illegible]	[illegible]3/	4432/	[illegible]	6332/	5331/	5734/	52	34/	[illegible]
71	30/	4932/	5232/	5033/	5824/	5[illegible]31/	4[illegible]3/	4832/	[illegible]	6934/	5334/	5427/	44	31/	[illegible]
72	33/	4432/	5932*	4817/	4[illegible]30/	56[illegible]/	3[illegible]5/	3733/	3733/	4235/	4[illegible]33/	4634/	44	32/	5[illegible]
73	33/	4335/	3835/	5613/	4[illegible]33/	421[illegible]	4[illegible]54/	4228/	5231/	3733/	4[illegible]27/	5331/	55	35/	[illegible]
74	26/	4233/	5625/	5432/	4128/	543[illegible]/	3725/	[illegible]32/	4332/	4422/	4[illegible]32/	5034/	44	3[illegible]/	[illegible]
75	33/	4831/	5832/	5732/	5219/	5431/	5725/	663[illegible]/	4734/	5[illegible]3/	4432/	6232/	44	25/	[illegible]
76	32/	5434/	5533/	5719/	4232/	6533/	5[illegible]21/	[illegible]32/	4633/	37[illegible]	4433/	5132/	57	32/	65
77	34/	6232/	6234/	5734/	4431/	4434/	4[illegible]33/	60[illegible]1/	4133/	6[illegible]32/	4732/	66			
MEAN		51.1	49.2	51.5	4[illegible].8	4[illegible].5	47.5	[illegible].9	45.7	4[illegible].3	4[illegible]	53.6	51.7		54.2
S D		8.495	8.411	8.607	8.556	7.590	[illegible]	[illegible].472	8.31[illegible]	[illegible]	[illegible]3[illegible]	7.[illegible]55	[illegible].474		[illegible]
TOTAL OBS		800	732	810	795	[illegible]	79[illegible]	810	83[illegible]	[illegible]	[illegible]6[illegible]	834	[illegible]		[illegible]72[illegible]

NOTES * (BASED ON LESS THAN FULL MONTHS)
$ (BASED ON LESS THAN FULL MONTHS [illegible] KNOTS)

Figure 4.2 Extreme Values of Surface Winds from Daily Observations, 1949-1977, Daily Peak Gusts in Knots.

[1] The prevailing wind direction is that direction containing the highest percent frequency of occurrence during the period under study. The prevailing wind direction can be misleading, though, if the percentages of several wind directions, which are larger than any of the other percentages, differ by only a few percent. For instance, if winds occur from the South 10.0 precent of the time, the West 9.5 percent of the time, and North 9.8 percent of the time, the prevailing wind direction is South. The mere statement to a customer that the prevailing wind direction is South, although true, could lead to an erroneous impression unless additional facts were presented.

[2] The percent 0.0 with speeds of 41-47 knots or more means that wind speeds greater than 41 knots occurred in so few cases that it is 0.0 in the mean after being rounded.

[3] The mean annual wind of 8.2 knots obtained in the preceding exercise includes observations with variables and calms. To find the mean wind speed for combinations of direction (N-ENE, SE-W, etc.) or for all directions, including variable, use the expression

$$M_I = (P_1M_1 + P_2M_2 + \dots + P_kM_k) / (P_1 + P_2 + \dots + P_k)$$

where M_I is the mean wind speed for the interval; $M_1, M_2, \dots, M_k$ are the mean wind speeds for each direction of the interval: and $P_1, P_2, \dots, P_k$ are the percent frequencies of occurrence associated with each direction. For this exercise, $M_1 = 10.6$, $M_2 = 7.0$, ..., $M_{17} = 5.0$; $P_1 = 11.3$, $P_2 = 2.8$ ..., $P_{17} = 0.0$; and $M_I = 816.22/86.2 = 9.5$ knots. If calms are included ($M_{18} = 0$ and $P_{18} = 13.8$), $M_I = 816.22/100 = 8.2$ knots as determined from the summary.

DATA PROCESSING BRANCH
ETAC/USAF
AIR WEATHER SERVICE/MAC

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

24005 | ELLSWORTH AFB SD/RAPID CITY | 67-77 | ALL
STATION | STATION NAME | YEARS | MONTH

ALL WEATHER | ALL
CLASS | HOURS (L.S.T.)

CONDITION

SPEED (KNTS) DIR.	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	22 - 27	28 - 33	34 - 40	41 - 47	48 - 55	≥ 56	%	MEAN WIND SPEED
N	.7	2.1	3.5	3.4	1.0	.4	.1	.0				11.3	10.0
NNE	.4	1.0	.9	.4	.0	.0	.0					2.8	7.7
NE	.4	.7	.5	.1	.0							1.7	5.9
ENE	.4	.7	.4	.1	.0	.0						1.6	5.7
E	.7	1.1	.8	.2	.0	.0						2.8	6.0
ESE	.5	.9	1.0	.4	.0	.0	.0					2.7	7.1
SE	.6	1.3	1.7	1.0	.2	.0	.0					4.9	8.2
SSE	.9	1.9	2.6	2.2	.5	.1	.0	.0				8.2	9.2
S	1.2	2.3	2.1	1.6	.5	.1	.0	.0				7.9	8.4
SSW	.6	.8	.3	.1	.0	.0						2.0	5.0
SW	.6	.8	.2	.1	.0	.0						2.0	4.7
WSW	1.2	1.2	.3	.2	.0	.0	.0	.0				3.0	5.0
W	2.5	2.5	.6	.3	.1	.0	.0					6.2	5.0
WNW	1.4	1.6	.7	.5	.2	.1	.0	.0	.0			4.6	7.0
NW	.8	1.7	1.8	2.0	1.4	1.2	.5	.2	.0			9.6	13.0
NNW	.6	1.6	3.1	4.6	2.8	1.7	.5	.2	.0	.0		14.9	14.2
VARBL		.0										.0	5.0
CALM												13.9	
	13.8	22.3	20.6	17.0	6.0	3.7	1.1	.4	.0	.0		100.0	8.2

TOTAL NUMBER OF OBSERVATIONS 87632

Figure 4.3. Percentage Frequency of Wind Direction and Speed from Hourly Observations, 1967-1977, All-Weather, All-Hours, All Months.

Table 4.3. Procedures for Determining Answers To Sample Questions from the January, All-hours All-Weather Surface Wind Summary (Figure 4.4, page 27). (Exercises for the summaries of this type in the RUSSWO for the other months of the year are omitted.)

To Find	Pertinent Row/Column	Answer
Direction and speed of the prevailing wind.	NNW/% and Mean Wind Speed	NNW 15.4[1]
Mean wind speed.	(Bottom row)/ Mean Wind Speed	8.5 kt
Direction containing the highest mean wind speed.	NNW/Mean Wind Speed	NNW
Mean wind speed which occurs from SSE-SSW.	SSE-SSW/% and Mean Wind Speed	7.11 kt[2]
Mean percentage of time that winds are calm.	Calm/%	17.4
Mean percentage of time that winds from 7 to 16 knots occur from the South.	S/7-16	2.1
Mean percentage of time that winds from 22 to 33 knots occur from the North.	N/22-33	0.8
Mean percentage of time that winds of 15 knots or 15 knots or less occur.	Bottom Row (see Footnote 3)	81.3
Mean percentage of time that winds blow from NE through S.	NE-S/1-3%, 4-6% 7-10%, 11-16%	20.9

DATA PROCESSING BRANCH
ETAC/USAF
AIR WEATHER SERVICE/MAC

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION	STATION NAME	YEARS	MONTH
24006	ELLSWORTH AFB SD/RAPID CITY	68-77	JAN

CLASS	HOURS (L.S.T.)
ALL WEATHER	ALL

CONDITION

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	[illegible]	2.1	3.4	[illegible]	1.7	.7	[illegible]					12.4	11.5
NNE	.3	.7	.7	.2	[illegible]		[illegible]					1.9	6.7
NE	.3	.5	.2	[illegible]								1.6	5.1
ENE	.2	.4	.2	.1								1.6	5.7
E	.5	.7	.5	[illegible]								2.0	5.8
ESE	.5	.6	.6	.2	[illegible]							1.9	6.4
SE	.5	1.1	1.[illegible]	1.[illegible]	.3	[illegible]						4.0	8.9
SSE	.3	1.3	1.7	1.3	.3	[illegible]						3.5	8.9
S	1.3	2.[illegible]	1.4	.7	.1	[illegible]						3.5	6.4
SSW	.7	.9	.1	[illegible]	[illegible]							1.6	4.0
SW	.7	1.[illegible]	.2	.1	[illegible]							2.3	4.8
WSW	1.2	1.9	.6	[illegible]	.2	[illegible]						4.4	6.2
W	2.5	3.2	1.1	[illegible]	.1	[illegible]	[illegible]					7.6	5.6
WNW	1.4	1.3	[illegible]	[illegible]	.4	[illegible]	[illegible]	[illegible]				5.0	9.9
NW	.5	1.4	1.5	2.4	1.7	1.7	.9	.2	[illegible]			10.6	15.1
NNW	.5	1.6	2.5	4.5	3.[illegible]	2.4	.7	.2	[illegible]	[illegible]		15.5	15.4
VARBL													
CALM												17.4	
	13.6	20.6	16.3	16.1	6.1	5.[illegible]	1.9	.4	[illegible]	[illegible]		100.0	6.5

TOTAL NUMBER OF OBSERVATIONS 7439

Figure 4.4. Percentage Frequency of Wind Direction and Speed from Hourly Observations, 1968-1977, All-Weather, All-Hours, January.

1 See Footnote 2, Table 4.2.

2 The mean wind speed for the interval SSE-SSW cannot be found by adding the three mean wind speeds for each direction (8.9, 6.4, and 4.0) and dividing by 3. The answer so obtained (6.4 knots) is incorrect because it does not give proper weight to the percent frequency of occurrence of winds from each direction. Refer to Footnote 3, Table 4.2 for details.

3 The foregoing value (81.3) can be obtained by adding the percentages for calm (17.4), 1-3 knots (13.6), 4-6 knots (20.6), 7-10 knots (16.3), and 11-15 knots (5/6 x 16.1). It is assumed that the 16.1 percent in the 11-16 knot block is evenly distributed among each of the speeds 11 through 16 knots and that 5/6 of this percentage should be added to the other block percentage to obtain the total. This assumption is sufficiently accurate for most purposes, but in reality the block percentage is not evenly distributed within its interval. In the case at hand, the percentage is probably distributed as follows: 11 knots (5.0), 12 knots (3.2), 13 knots (2.4), 14 knots (2.1), 15 knots (1.8), and 16 knots (1.6). The probable error in the first figure (81.3) does not exceed a few percent if the last subjective distribution is accepted as the real one.

Table 4.4. Procedures for Determining Answers To Sample Questions from the November 0000-0200 Local Standard Time (LST), All-Weather Surface Winds Summary (Figure 4.5, page 29). (Exercises for the summaries of this type in the RUSSWO for the other 3-hour groups and months of the year are not included.)

To Find	Pertinent Row/Column	Answer
Mean wind speed.	(Bottom Row)/ Mean Wind Speed	6.7 kt

Table 4.4 - Continued

To Find	Pertinent Row/Column	Answer
Direction and speed of the prevailing wind.	W/% and Mean Wind Speed	W 4.6 kt[1]
Direction and speed of that wind which is second only to the prevailing wind direction in percentage frequency of occurrence.	NW/% and Mean Speed	NW 13 kt
Direction containing the third highest mean wind speed.	N/Mean Wind Speed	N
Direction containing the lowest mean wind speed.	E/Mean Wind Speed	E
Mean wind speed, excluding calms.	(All Directions)/% and Mean Wind Speeds	8.3[2]
Mean percentage of time that winds occur from NNW, N, and NNE.	NNW, N, NNE/%	19.7
Mean percentage of time that winds are calm.	Calm/%	20.0
Mean percentage of time that winds are 10 knots or less.	Calm/% and (Bottom Row)/ 1-10	77.6
Mean percentage of time that winds of 4-16 knots occur.	(Bottom Row)/ 4-16	49.9
Mean percentage of time that winds greater than 40 knots occur.	(Bottom Row)/ 41-≥56	0[3]
Direction from which winds are observed the least percent of time.	ESE/%	ESE
Direction containing the highest percentage of winds from 7 to 10 knots and the percentage frequency.	NW/7-10	NW, 2.6

[1] See Footnote 1, Table 4.2.

[2] To find the mean wind speed for combinations of directions (N-ENE, SW-W, etc.) or for all directions including variable, use the expression

$$M_I = (P_1 M_1 + P_2 M_2 + \ldots + P_k M_k) / (P_1 + P_2 + \ldots + P_k)$$

where M_I is the mean wind speed for the interval; $M_1, M_2, \ldots, M_k$ are the mean wind speeds for each direction of the interval; and $P_1, P_2, \ldots, P_k$ are the percent frequencies of occurrence associated with each direction. For this exercise, $M_1 = 12.3$, $M_2 = 5.8$, ... $M_{17} = 0$ $P_1 = 6.5$, $P_2 = 2.2$, ... P_{17} and $M_I = 667.2/80 = 8.3$ knots.

[3] The lack of an entry in this summary for winds exceeding 40 knots denotes that no occurrences were observed during 1968 through 1977.

Table 4.5. Procedures for Determining Answers To Sample Questions from the All-Months, All-Hours Instrument - Weather[1] Surface Winds Summary (Figure 4.6, page 30).

DATA PROCESSING BRANCH
ETAC/USAF
AIR WEATHER SERVICE/MAC

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION	STATION NAME	YEARS	MONTH
24006	ELLSWORTH AFB SD/RAPID CITY	68-77	NOV

CLASS	HOURS (L.S.T.)
ALL WEATHER	0000-0200

CONDITION

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	.4	1.4	.7	2.	.9	.	.2					6.5	12.3
NNE	.4	1.0	.3									7.2	5.8
NE	.1	.9	.2									1.2	4.9
ENE	.4	.4		.1								1.0	4.1
E	.7	.1	.1									.9	3.5
ESE	.2		.2									.4	5.5
SE	.1	.2	1.3	[illegible]								2.5	9.3
SSE	.7	1.0	.8	1.	.1							3.6	7.9
S	1.2	1.7	.9	[illegible]	.3							4.8	6.8
SSW	.4	.2	.2	.1		.1						1.1	7.5
SW	1.2	1.2										2.5	3.5
WSW	2.3	2.5	.3	.3								5.5	4.6
W	6.1	5.8	1.6	.6	.1							14.4	4.6
WNW	3.5	2.9	1.1	.3	.3							9.2	5.2
NW	1.7	2.3	2.6	3.	2.	1.7	.3	.2				14.3	13.0
NNW	.4	2.1	2.2	3.6	2.5	.3	.3					11.0	12.5
VARBL													
CALM												20.0	
	20.2	23.9	15.5	12.5	5.6	2.7	1.3	.2				100.0	6.7

TOTAL NUMBER OF OBSERVATIONS 897

Figure 4.5. Percentage Frequency of Wind Direction and Speed from Hourly Observations, 1968-1977, All-Weather, 0000-0200 LST, November.

Table 4.5 - Continued

To Find	Pertinent Row/Column	Answer
Annual prevailing wind (direction and speed).	N/% and Mean Wind Speed	N 11.7 kt[2]
Mean annual percentage of time that winds are calm.	Calm/%	7.2
Mean annual percentage of time that winds occur from NNW-ENE.	NNW-ENE/%	58.1
Mean annual wind speed.	(Bottom Row)/ Wind Speed	10.6 kt
Direction with the lowest mean wind speed.	SW/Mean Wind Speed	SW 3.1 kt
Directions with mean wind speeds of 11 knots or more.	N,NW,NNW/Mean Wind Speed	N, NW NNW
Mean annual percentage of the time that winds between 11-21 knots occur.	(Botton Row)/ 11-21	31.3
Mean annual percentage of time that winds exceed 21 knots.	(Bottom Row)/ 22->56	10.0
Mean annual percentage of time that winds of 10 knots or less occur.	Calm/% and (Bottom Row)/ 1-10	58.7
Mean annual percentage of time that winds between 22 to 40 knots occur from N.	N/22-40	1.5

DATA PROCESSING BRANCH
ETAC/USAF
AIR WEATHER SERVICE/MAC

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

24006 (STATION) ELLSWORTH AFB SD/RAPID CITY (STATION NAME) 67-77 (YEARS) ALL (MONTH)

I STRUMENT (CLASS) ALL (HOURS (L.S.T.))

CIG 200 TO 14[illegible] FT W/ VSBY 1/2 MI OR [illegible] (CONDITION)

AND/OR VSBY 1/2 TO 2-1/2 MI W/CIG 200 FT [illegible]

SPEED (KNTS) DIR.	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	22 - 27	28 - 33	34 - 40	41 - 47	48 - 55	≥56	%	MEAN WIND SPEED
N	1.1	3.6	6.7	7.2	2.6	1.1	.2	.1				22.9	11.7
NNE	.7	2.1	3.1	1.2	.1		[illegible]					7.1	7.[illegible]
NE	.6	1.6	1.6	.2								4.0	6.3
ENE	.4	1.2	1.0	.2	.0	[illegible]						2.9	6.5
E	[illegible]	1.6	1.6	.4	.1							4.5	6.[illegible]
ESE	.7	1.4	1.6	.9	.2	[illegible]	[illegible]					5.0	7.9
SE	.6	1.9	2.5	1.5	.5	[illegible]	[illegible]					7.0	9.0
SSE	.6	1.3	2.3	1.9	.3	.1						6.4	9.0
S	.6	1.0	1.1	.7	.1	.1						3.5	7.8
SSW	.1	.1	.1									.3	4.5
SW	.1	.0	.0									.2	3.1
WSW	.2	.0	.0	[illegible]								.2	3.4
W	.2	.2	.0	[illegible]								.4	4.3
WNW	.2	.3	[illegible]	.1		.1	.0	.0				.7	10.8
NW	.5	.7	.6	.9	1.0	1.[illegible]	.6	.2				6.3	17.8
NNW	.4	1.2	3.2	6.1	4.0	4.[illegible]	1.2	.3				21.2	16.7
VARBL													
CALM												7.[illegible]	
	7.7	18.2	25.6	21.4	9.9	[illegible]	2.4	.7				100.0	10.6

TOTAL NUMBER OF OBSERVATIONS 5739

Figure 4.6. Percentage Frequency of Wind Direction and Speed from Hourly Observations, 1967-1977, Instrument, All-Hours, All-Months, Ceiling 200 to 1400 Feet With Visibility 1/2 Miles or More, and/or Visibility 1/2 to 2-1/2 Miles With Ceiling 200 Feet or More.

Table 4.5 - Continued

To Find	Pertinent Row/Column	Answer
Mean annual percentage of time that winds exceed 16 knots from N.	N/17-≥56	4.3
Mean annual percentage of time that winds are less than 11 knots from S.	S/1-10	2.7
Mean annual percentage of time that winds between 7 to 16 knots occur from W to N.	W-NW-N/7-16	24.8
Mean annual percentage of time that winds between 4 to 21 knots occur from E to S.	E-S/4-21	23.1
Directions whose mean wind speeds exceed the mean annual wind speed.	WNW-N/Mean Wind	WNW-N

[1] Instrument weather is defined as ceiling 200 to 1400 feet with visibility equal to or greater than 0.5 mile, and/or visibility 0.5 to 2.5 miles with ceiling equal to or greater than 200 feet.

[2] See Footnote 1, Table 4.2.

Chapter 5

CEILING AND VISIBILITY (PART D)

5.1 General

Part D, Ceiling Versus Visibility, has one section with a bivariate percentage frequency distribution of visibility (statute miles) versus ceiling height (feet). A cumulative form is contained in both arguments so the intersection of ceiling ≥ 0 feet and visibility ≥ 0 statute mile will equal 100 percent. Higher classes include no ceiling and range from ≥ 20,000 feet down to ≥ 0 feet. Visibility classes vary from ≥ 10 miles down to ≥ 0 mile. Data are summarized by months and year, and by months for eight 3-hourly periods. A second section, Sky Cover, has the percentage frequency of occurrence of total sky cover by tenths, and mean tenths of sky cover (zero includes ≤ 1/10; 10/10 includes 9+ tenths). Data are summarized by month and year, and by months for eight 3-hourly groups.

5.2 Ceilings and Visibilities

The bivariate ceiling and visibility summaries (see for example, Figure 5.8, page 36) give the percentage frequencies of occurrence of specified ceiling conditions, specified visibilities, and the joint occurrence of combined ceiling and visibility conditions. The far right column of the table is the cumulative distribution of ceiling heights since all visibilities are included in the visibility ≥ 0 category. Similarly, the bottom row gives the cumulative distribution of visibilities (ceiling ≥ 0). The main body of each table contains the joint occurrence values. Also given with each table is the number of observations used.

The ceiling versus visibility summaries are derived from hourly observations. For stations with limited observing hours, the monthly-hourly summaries will not address those hours for which no observations are to be had. Before 1949 US Weather Bureau and Navy Stations did not report ceilings of 10,000 feet or greater. Summaries for the stations based on pre-1947 data are thus limited to ceilings below 10,000 feet. For Air Force stations up through June 1948, the "no ceiling" category included clear conditions, scattered conditions, and ceilings above 20,000 feet. Beginning in July 1948 for Air Force stations and in January 1949 for US Weather Bureau and Navy stations, the "no ceiling" category includes all hourly observations with less than 6/10 total sky cover and those observations with 6/10 or more sky cover but where less than half of the sky cover is opaque.

Beginning in January 1968, METAR stations report actual visibilities up to 6 miles (9000 m) and then all visibilities greater than 6 miles are lumped together (as 9999 m). Thus, for METAR stations, the category equal to or greater than 10 miles is not printed in the tables, unless the summary was for a period ending before January 1968. NOTE: METAR observations are taken in nautical miles (nm). So that a RUSSWO might truly be a uniform summary, the same format and units are used for all locations; nautical mile visibilities have therefore been converted to statute miles (sm), and all visibilities in the RUSSWO are in statute miles. If nautical mile visibilities are desired, simple linear interpolation can be used. An adequate system of conversion is given in Table 5.1. For those METAR stations reporting "CAVOK" all values > 5000 feet and > 3 miles are grouped with those equal to 5000 feet and equal to 3 miles.

Table 5.1 RUSSWO Conversions from Statute to Nautical Miles.

EXACT CONVERSION	RUSSWO APPROXIMATION
1/2 nm = 0.5 sm	(1/2 + 5/8)/2
1 nm = 1.15 sm	(1 + 1 1/4)/2
1 1/2 nm = 1.725 sm	(1 1/2 + 2)/2
2 nm = 2.30 sm	(2 + 2 1/2)/2
3 nm = 3.5 sm	(3 +4)/2
4 nm = 4.6 sm	(4 + 5)/2
5 nm = 5.8 sm	6

When using the Ceiling Versus Visibility Summary care must be taken lest semantics lead us astray. Consider for instance the row for ceilings $\geq$ 5000 feet and the column for visiblity $\geq$ 3 sm. The intersection of this row and column shows the percentage frequency of occurrence of ceiling $\geq$ 5000 feet AND visibilities $\geq$ 3 sm (83.3 percent from Figure 5.8, page 36). If we subtract this value from 100 percent (100.0 - 83.3 = 16.7) we get the percentage frequency of occurrence of ceilings < 5000 feet AND/OR visibilities < 3 sm. To determine the frequencies with which we can expect ceilings AND visibilities below given limits, as well as other combinations of ceiling above ...., and visibility below ..., etc; we can use a contingency table.

5.2.1 Contingency Tables. A contingency table (see Figure 5.1, page 32) is basically an N x M array. In our illustration we have a 3 x 3 array with nine areas (labeled A-I) for specified categories and percentages. From these data in the RUSSWO we can fill in some blocks immediately (see Figure 5.1). Since our categories are mutually exclusive, the totals must sum to 100 percent, thus block I is 100.0. From row "Ceiling $\geq$ 5000 feet" and column "visibility $\geq$ 0" (see Figure 5.8) we get a value for block C of 83.6. Block F is then simply 100.0-83.6 = 16.4. Next, from the visibility column $\geq$ 3 and the ceiling row $\geq$ 5000 feet we find, at the column-row intersection, the value for block B (83.3, see Figure 5.2). Similarly, for visibility $\geq$ 3 and ceiling $\geq$ 0 we get 95.7 for block H. We can now complete our contingency table.

Block E is determined by E = 95.7 - 83.3 = 12.4. Blocks A, D, and G are now found as

A = 83.6 - 83.3 = 0.3

D = 16.4 - 12.4 = 4.0

G = 100.0 - 95.7 = 4.3

and so our contingency table is filled (Figure 5.3, page 33).

With our completed contingency table (Figure 5.3) we can now answer questions such as "What is the percent frequency of occurrence, of ceilings below 5000 feet AND visibilities below 3 sm?" (Answer: 4.0) and "What is the percentage frequency of occurrence of ceilings at 5000 feet or above, but visibilities below 3 statute miles?" (Answer: 0.3) and so on.

CIG / VSBY	<3	$\geq$3	TOTAL ($\geq$0)
$\geq$5000	A	B	C
<5000	D	E	F
TOTAL ($\geq$0)	G	H	I

Figure 5.1. A Simple Contingency Table.

CIG / VSBY	<3	$\geq$3	TOTAL ($\geq$0)
$\geq$5000	A	83.3	83.6
<5000	D	E	16.4
TOTAL ($\geq$0)	G	95.7	100.0

Figure 5.2. Partially Completed Contingency Table.

CIG/ VSBY	<3	≥3	TOTAL (≥0)
≥5000	0.3	83.3	83.6
<5000	4.0	12.4	16.4
TOTAL (≥0)	4.3	95.7	100.0

Figure 5.3. Completed Contingency Table.

Let us now look at another contingency table exercise. Although the question may seem a bit obtuse, it is just the sort of question that customers actually ask and that we have to answer. Suppose we want to find the percentage frequency of "ceiling ≥ 300 feet and visibilities ≥ 3/4 miles but < 4 miles, or ceilings ≥ 300 feet but < 2,000 feet with visibilities ≥ 3/4 miles." We start with a 4 x 4 contingency table as shown in Figure 5.4 (page 33) and immediately fill in what we can from the RUSSWO (see Figure 5.8, page 36). The values in blocks A, H, L, M, and N are calculated directly (A = 90.5 - 90.4, H = 98.6 - 90.5, L = 100.0 - 98.6, M = 100.0 - 98.5, N = 98.5 - 94.8).

Consider now that the sum of the percentages in blocks B, C, F, and G is the percentage frequency of ceilings ≥ 300 feet and visibilities ≥ 3/4 of a mile (= 97.9 from the RUSSWO). Thus, B + C + F + G = 97.9, but C is already known to be 89.7, so we get B + F + G = 8.2. This number is the answer to the question asked, but further information can be gained by completing the contingency table.

CIG/ VSBY	<3/4	≥3/4 to <4	≥4	TOTAL (≥0)
≥2000	A	B	89.7	90.5
≥300 to <2000	E	F	G	8.1
<300	I	J	K	1.4
TOTAL (≥0)	1.5	3.7	94.8	100.0

Figure 5.4. Initial Filling of 4 x 4 Contingency Table.

CIG/ VSBY	<3/4	≥3/4 to <4	≥4	TOTAL (≥0)
≥2000	0.1	0.7	89.7	90.5
≥300 to <2000	E	F	G	8.1
<300	I	J	K	1.4
TOTAL (≥0)	1.5	3.7	94.8	100.0

Figure 5.5. Partially Completed 4 x 4 Contingency Table.

CIG/ VSBY	<3/4	≥3/4 to <4	≥4	TOTAL (≥0)
≥2000	0.1	0.7	89.7	90.5
≥300 to <2000	E	2.5	5.0	8.1
<300	I	J	K	1.4
TOTAL (≥0)	1.5	3.7	94.8	100.0

Figure 5.6. Last Step of 4 x 4 Contingency Table Prior to Completion.

CIG/VSBY	<3/4	≥3/4 to <4	≥4	TOTAL (≥0)
≥2000	0.1	0.7	89.7	90.5
≥300 to <2000	0.6	2.5	5.0	8.1
<300	0.8	0.5	0.1	1.4
TOTAL (≥0)	1.5	3.7	94.8	100.0

Figure 5.7. Completed Contingency Table.

B is simply found as 90.4 (≥ 2000/≥ 3/4 from Figure 5.8) - C = 89.7, or B = 0.7. This then gives A = 0.10 directly (see Figure 5.5). G is found as 94.7 (≥ 300/≥ 4 from Figure 5.8) minus C, or 94.7 - 89.7 = 5.0. Then, since we had earlier that B + C + F + G = 97.9, we can now solve for the remaining unknown F = 2.5 which gives us the table in Figure 5.6. The completion of the contingency table is trivial: K = 94.8 - 5.0 - 89.7 = 0.1, J = 3.7 - 2.5 - 0.7 = 0.5, E = 8.1 - 2.5 - 5.0 = 0.6, and I = 1.5 - 0.6 - 0.1 = 1.4 - 0.5 - 0.1 = 0.8, which gives us Figure 5.7 (page 34).

Careful study of this example will show what is to be taken from the RUSSWO and what must be calculated. Note how many different ceiling and visibility ranges we have now evaluated and how much information that is not explicitly stated in the RUSSWO has been found.

5.2.2 <u>Other "Indirect" Methods</u>. Since our customers often have a proclivity for asking for climatological data not immediately available, let us look at a few more examples of how to find or approximate derived data from the RUSSWO's D-Summary.

As noted earlier, the RUSSWO gives ceiling and visibility data as percentage frequencies of conditions "GREATER THAN OR EQUAL TO" specified lower limits. We have already seen how to find "LESS THAN" values. Now, what do we do in the case of needing a "LESS THAN OR EQUAL TO" value? Here, we must make an assumption which allows us to approximate the desired answer. We assume that only the RUSSWO categories of ceilings and visibilities can occur so that 100 percent minus the next higher "≥ category" will give us the desired "≤ category." Thus, to find the percentage frequency of occurrence of, say, ceilings ≤ 1000 feet, we see from Figure 5.8 (page 36) that ceilings ≥ 1200 feet occur 92.9 percent of the time so that ceilings ≤ 1000 feet can be expected 100.0 - 92.9 = 7.1 percent of the time. Clearly this approximation is most valid for the lower ranges of ceilings and visibilities where the separation between adjacent categories is small.

Table 5.2 gives a series of illustrative examples of using the Ceiling Versus Visibility summary.

Table 5.2. Exercises for the Ceiling Versus Visibility Summaries. (The following exercises are based on Figure 5.8, page 36 the all-months, all-hours summary. Similar methods apply to the monthly and hourly summaries.)

To Find	Pertinent Row/Column	Answer
Mean annual percentage of time with no ceiling	No Ceiling/≥0	61.0
Mean annual percentage of time with no ceiling and visibility ≥ 6 statute miles.	No Ceiling/≥6	60.7
Mean annual percentage of time with ceilings below 3000 feet.	≥3000/≥0	11.9[1]
Mean annual percentage of time with visibilities ≥ 3 statute miles.	≥0/≥3	95.7

Table 5.2 - Continued

To Find	Pertinent Row/Column	Answer
Mean annual percentage of time with 3 statute miles ≤ visibilty < 5 statute miles.	≥0/≥5 and ≥3	1.5[2]
Mean annual percentage of time with 500 feet ≤ ceiling < 1000 feet.	≥500 and ≥1000/0	2.8
Mean annual percentage of time with ceiling < 3000 feet and/or visibility < 3 statute miles.	≥3000/≥3	12.2
Mean annual percentage of time with ceilings from 200 feet to 1500 feet and with visibility from 0.5 to 1.5 statute miles.	≥1500/≥1.5 ≥200/≥0.5	7.3
Mean annual percentage of time with ceilings below 3000 feet and visibility below 3 statute miles.	See Footnote 3	4.0
Mean annual percentage of time with ceilings ≥ 3000 feet and visibility ≥ 3 statute miles.	≥3000/≥3 and ≥3000/≥4 (see also Table 5.1)	87.7

[1] Since the percentages given are for conditions GREATER THAN OR EQUAL TO to find the percentage for below a set value, simply subtract the appropriate table value from 100. In this case: 100.0 - 88.1 = 11.9.

[2] To determine the percentage frequency of occurrence of a range of values, simply find the difference between the values at the end points of the specified range. In this example; 95.7 - 94.2 = 1.5.

[3] With reference to Table 5.2 we have *(0/0)* - *(0/3)* - [*(3000/0)* - *(3000/3)*] = 100.0 - 95.7 - [88.1 - 87.8] = 4.0.

5.3 Sky Cover

The second section of Part D of the RUSSWO gives the percentage frequency of occurrence of sky cover in tenths by month and by 3-hour time block. Sky cover is derived from hourly observations.

Sky cover is defined as that amount of the sky that is filled with clouds or otherwise obscured. Hence, a clear sky has zero sky cover and a total overcast or obscuration would have 10 tenths sky cover. In those cases where sky cover is reported in octas (eighths), the octas are converted to tenths according to Table 5.3 and entered in the RUSSWO in tenths.

No sky cover data were reported by US stations until mid-1945. All available sky cover data have been entered in the USAFETAC data base. Earliest dates for sky cover data are sometime in 1945 for US Weather Bureau stations; 1946 for Air Force stations; and 1948-49 for Navy stations.

Starting in January 1971, Airways sky cover data have been taken directly from transmitted weather observations as opposed to being taken from the actual forms on which the observations were written. Since sky cover per se is not transmitted, a conversion is made from the clear, scattered, broken, overcast, partially obscured and obscured of airways observations to tenths of sky cover. Table 5.4 shows this conversion. For METAR stations the only way to get sky cover data is to manually extract it from the AWS Form 10a. Since this is the era of automation and reduced manning, such manually intensive operations are anathema and have not been performed. Older RUSSWOs will contain full tables of sky cover data. More recent ones (produced since the mid-1970s) will generally have full data based on a period of record ending with December 1970. Newer RUSSWOs will have incomplete tables with data only in the columns for 0, 3, 9,

DATA PROCESSING BRANCH
USAF ETAC
AIR WEATHER SERVICE/MAC

CEILING VERSUS VISIBILITY

24004 ELLSWORTH AFB SD/RAPID CITY 7-77 ALL

PERCENTAGE FREQUENCY OF OCCURRENCE
(FROM HOURLY OBSERVATIONS) ALL

CEILING (FEET)	≥10	≥6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NO CEILING	60.6	60.7	60.8	60.8	60.9	[illegible]	[illegible]	[illegible]	[illegible]	60.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	61.1
≥ 20000	67.0	67.1	67.2	67.3	67.3	67.3	[illegible]	[illegible]	67.3	67.4	67.4	67.4	67.4	67.4	67.4	67.4
≥ 18000	67.4	67.5	67.6	67.6	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.8	67.8	[illegible]	67.9
≥ 16000	67.7	67.9	68.0	68.0	68.1	68.1	[illegible]	68.1	68.1	68.1	68.1	68.1	68.1	68.2	68.2	68.2
≥ 14000	68.9	69.1	69.2	69.2	69.3	69.3	[illegible]	69.3	69.3	69.4	69.4	69.4	69.4	69.4	69.4	69.4
≥ 12000	71.3	71.5	71.6	71.6	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.8	71.8	71.8	71.8
≥ 10000	75.1	75.4	75.5	75.5	75.6	75.6	[illegible]	75.6	75.6	75.7	75.7	75.7	75.7	75.7	75.7	75.7
≥ 9000	75.8	76.0	76.1	76.2	[illegible]	[illegible]	[illegible]	76.3	76.3	76.3	[illegible]	[illegible]	76.4	76.4	[illegible]	76.4
≥ 8000	77.5	[illegible]	77.9	[illegible]	[illegible]	[illegible]	[illegible]	78.1	78.1	78.1	78.1	78.1	[illegible]	78.1	78.2	78.2
≥ 7000	78.8	79.1	79.2	79.3	79.4	79.4	[illegible]	79.4	79.4	79.5	79.5	79.5	79.5	79.5	79.5	79.6
≥ 6000	80.4	80.7	80.9	80.9	[illegible]	81.0	81.0	81.1	81.1	81.1	81.1	81.1	81.2	81.2	81.2	81.2
≥ 5000	82.6	83.0	83.1	83.2	83.3	83.4	[illegible]	83.4	83.4	83.5	83.5	83.5	83.5	83.5	[illegible]	83.6
≥ 4500	83.1	83.5	83.7	83.8	83.9	83.9	83.9	84.0	84.0	84.0	84.1	84.1	84.1	84.1	84.1	84.1
≥ 4000	84.4	84.7	85.1	85.2	85.4	85.4	[illegible]	85.5	85.5	85.6	85.6	85.6	85.6	85.6	[illegible]	85.7
≥ 3500	85.2	[illegible]	86.0	86.1	86.3	[illegible]	[illegible]	86.4	86.4	86.5	86.5	86.5	86.5	86.5	[illegible]	86.5
≥ 3000	86.4	87.1	87.4	87.6	87.6	87.9	87.9	87.9	88.0	88.0	[illegible]	88.1	88.1	88.1	88.1	88.1
≥ 2500	87.2	88.0	38.3	88.5	88.7	[illegible]	[illegible]	88.9	89.0	89.1	89.1	89.1	89.1	89.1	89.1	89.2
≥ 2000	98.1	89.0	89.4	89.7	89.9	90.0	[illegible]	90.2	90.3	90.4	90.4	90.4	90.4	90.4	90.5	90.5
≥ 1800	88.3	89.2	89.7	89.9	90.2	90.2	[illegible]	90.5	90.5	90.6	90.7	90.7	90.7	90.7	90.7	[illegible]
≥ 1500	89.0	90.1	90.6	90.9	91.2	91.3	91.5	91.6	91.6	91.8	[illegible]	[illegible]	91.9	91.9	[illegible]	91.9
≥ 1200	89.5	90.8	91.3	91.6	92.0	92.1	92.3	92.5	92.5	92.7	92.7	92.7	92.8	92.8	[illegible]	92.9
≥ 1000	90.0	91.4	92.0	92.4	[illegible]	92.9	93.2	93.4	93.5	93.7	93.8	93.8	93.9	93.9	[illegible]	94.0
≥ 900	90.2	91.6	92.2	92.6	93.1	93.1	93.4	93.7	93.8	94.0	94.1	94.1	94.2	94.2	94.2	94.3
≥ 800	90.4	91.9	92.5	92.9	93.4	93.5	[illegible]	94.1	94.2	94.4	94.5	94.6	94.7	94.7	[illegible]	[illegible]
≥ 700	90.5	92.1	92.6	93.2	93.7	93.8	94.2	94.5	94.6	94.9	[illegible]	95.1	95.2	95.2	95.3	95.3
≥ 600	90.6	92.3	93.1	93.5	94.1	94.2	94.5	94.9	95.1	95.4	95.5	95.6	95.7	95.7	[illegible]	95.9
≥ 500	90.8	92.7	93.5	[illegible]	94.6	94.7	95.1	95.5	95.8	96.1	96.3	96.4	96.6	96.5	96.7	[illegible]
≥ 400	91.0	92.9	93.9	94.4	[illegible]	95.3	[illegible]	96.2	96.5	96.9	97.1	97.2	97.4	97.5	97.6	97.7
≥ 300	91.1	93.1	94.1	94.7	95.5	[illegible]	[illegible]	96.7	97.1	97.5	97.9	98.0	98.2	98.3	98.4	98.5
≥ 200	91.1	93.2	94.2	94.8	95.7	95.8	[illegible]	97.0	97.5	98.0	98.4	98.6	98.9	[illegible]	99.2	99.5
≥ 100	91.1	93.2	94.2	94.8	95.7	95.8	[illegible]	97.1	97.5	98.1	98.5	99.7	99.1	99.2	99.5	99.9
≥ 0	91.1	93.2	94.2	94.8	95.7	95.8	[illegible]	97.1	97.5	98.1	[illegible]	99.7	99.1	99.2	99.5	100.0

TOTAL NUMBER OF OBSERVATIONS 87619

Figure 5.8. Percentage Frequency of Occurrence from Hourly Observations, 1967-1977, Ceiling Versus Visibility, All-Hours, All-Months.

Table 5.3. Octas - Tenths Conversion.

Octas	Tenths
0	0
1	1
2	3
3	4
4	5
5	6
6	8
7	9
8 (or obscured)	10

and 10 tenths. For any sky cover summary whose period of record includes both pre- and post-1970 data, only the 0, 3, 9 and 10 tenths columns are given. Data for 1970 and earlier were converted to the four-category system before preparing the summary.

Table 5.4. Airways Sky Conditions to Sky Cover Conversion.

Airways	Sky Cover
Clear	0
Scattered	3
Broken	9
Overcast	10
Partially Obscured	9
Total Obscuration	10

Chapter 6

PSYCHROMETRIC SUMMARIES (PART E)

6.1 General

Part E, Psychrometric Summaries, has one section with the cumulative percentage frequency of occurrence in 5°F intervals of daily maximum, minimum, and mean temperatures from daily observations, along with means and standard deviations. A second section of Part E has extreme daily temperatures, maximum and minimum, from daily observations for each year-month of record, and monthly and annual means and standard deviations. A third section has a bivariate percentage frequency distribution of wet-bulb depression classes versus dry-bulb temperatures. Also included is the raw frequency of occurrence of dry-bulb, wet-bulb, and dew-point temperatures in 2°F intervals. A summary block contains the sums of squares, sum, mean, and standard deviation of relative humidity, dry-bulb, wet-bulb, and dew-point temperatures, and also the mean number of hours with temperatures ≤ 0, ≤ 32, ≥ 67, ≥ 73, ≥ 80, and ≥ 93°F. Data are by month and year. A fourth section has means and standard deviations of dry-bulb, wet-bulb, and dew-point temperatures by month and year for 3-hourly groups and for all hours combined. The final section, relative humidity, has cumulative percentage frequencies of occurrence of relative humidity greater than 10, 20, 30, 40, 50, 60, 70, 80, and 90 percent, and the mean relative humidity. Data are by month and year, by month for eight 3-hourly groups, and for all hours combined.

Because the temperatures are given in degrees Fahrenheit, certain minor departures from the actual observations may occur in the summations, especially when discrete values are concerned. This is because all surface data at USAFETAC are stored in DATSAV format (see USAFETAC TN 77-2) wherein temperatures are kept in terms of Kelvins, and because data from METAR stations are reported in degrees Celsius. Thus, two conversions may be involved. One is for degrees Fahrenheit to degrees Celsius and back ($F = 9/5C + 32$; $C = 5/9(F-32)$). The other is to convert from degrees Celsius to Kelvin ($K = 273.16 + C$). Some data processing routines convert from degrees Celsius to Kelvins using the factor 273.2. The bottom line is, that minor differences (on the order of 1°F) may arise due to conversions and to rounding, but these differences do not affect the meaningfulness nor the representativeness of the psychrometric data presented in the summaries.

6.2 Cumulative Percentage Frequency of Occurrence - Daily Temperatures

Three summaries, one each for the maximum (Figure 6.1), minimum (Figure 6.2), and mean (Figure 6.3) daily temperatures, are given for cumulative percentage frequency of occurrence. The tabulated values are the percentage frequencies with which the specified temperature is equalled or exceeded. For example, if a daily maximum temperature in January of, say, 50°F is of concern, Figure 6.1 shows that on only 14.6 percent of the days in January, or on only 4 to 5 days, will the daily maximum temperature equal or exceed 50°F, according to climatology.

A convenient way to display cumulative percentage frequencies is to draw a graph such as Figure 6.4. In this example we plotted the annual cummulative percentage frequencies of occurrence of the daily maximum temperature. The resulting curve is called an "ogive" (ō-jīv). From a curve like Figure 6.4 we can easily answer such questions as: "What maximum temperature is equalled or exceeded 25 percent of the time?" Answer: 77.3°F; "What daily maximum temperature is equalled or exceeded 90 percent of the time?" Answer: 28°F.

The three "Daily Temperature" summaries (maximum, minimum, and mean) are derived from daily (i.e., Summary of the Day) observations. Beginning in January 1964, the daily maximum and minimum temperatures were selected from hourly observations. For stations reporting less than 24-hours per day, and where maximum and minimum temperatures are required but not recorded, these are also selected from the available hourly observations. This procedure has been followed since January 1949. The user must pay close attention to notes on the summary pages and in the Station History for further information on reporting practices at individual stations.

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DAILY TEMPERATURES

24006 (STATION) ELLSWORTH AFB SD/RAPID CITY (STATION NAME) 48-77 (YEARS)

CUMULATIVE PERCENTAGE FREQUENCY OF OCCURRENCE
(FROM DAILY OBSERVATIONS)

MAXIMUM

TEMP °F	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
≥ 110							.1						.0
≥ 105						.2	.5	.2					.1
≥ 100						.9	3.0	3.1	.7				.7
≥ 95					.1	3.1	14.2	13.5	2.0				2.8
≥ 90					.5	8.7	33.5	33.7	9.2	.5			7.3
≥ 85				.4	5.1	22.2	57.0	54.2	21.0	3.4			13.9
≥ 80			.3	3.1	13.2	38.3	76.1	73.3	35.8	10.4			21.2
≥ 75			1.0	8.4	25.7	58.0	90.1	87.4	51.8	17.8	.2		28.9
≥ 70		.4	3.4	16.9	39.8	75.9	96.9	93.7	65.1	30.4	3.6	.4	36.1
≥ 65	.6	1.6	6.9	27.1	57.7	89.0	98.8	97.8	76.3	46.0	9.9	1.1	43.3
≥ 60	2.7	6.4	14.2	39.3	74.9	95.2	99.6	99.6	85.7	60.1	19.1	5.1	50.9
≥ 55	6.9	13.1	22.1	53.4	85.2	98.4	99.9	100.0	92.4	72.4	29.7	11.8	57.8
≥ 50	14.6	22.1	33.1	66.1	92.7	99.4	100.0		96.2	80.3	44.9	20.0	64.8
≥ 45	25.1	34.1	44.7	78.0	97.0	99.8			98.4	89.9	57.6	32.3	72.0
≥ 40	37.6	47.1	57.4	87.3	98.4	99.9			99.8	95.2	69.6	46.3	78.7
≥ 35	49.9	57.9	69.4	94.1	99.8	100.0			100.0	97.3	79.1	59.5	84.2
≥ 30	60.3	69.3	79.5	99.3	100.0					99.4	88.0	72.3	89.3
≥ 25	68.6	77.3	87.8	99.7						99.7	92.9	80.4	92.4
≥ 20	74.9	84.8	94.0	99.9						100.0	95.6	88.2	94.8
≥ 15	81.1	91.7	97.1	100.0							97.9	91.2	96.7
≥ 10	86.4	95.5	98.8								99.3	95.2	98.0
≥ 5	91.2	98.4	99.6								99.7	97.2	98.9
≥ 0	94.7	99.6	99.8								100.0	98.9	99.4
≥ -5	97.9	100.0	100.0									99.2	99.8
≥ -10	99.4											99.9	99.9
≥ -15	100.0											100.0	100.0
MEAN	31.6	37.0	42.3	55.6	66.5	76.3	85.4	84.7	73.6	62.1	46.2	36.9	58.2
S D	17.337	15.289	14.952	13.272	11.311	9.997	8.378	9.000	12.578	13.360	14.087	14.902	22.653
TOTAL OBS	899	818	899	900	930	900	930	930	900	930	899	899	10834

Figure 6.1. Cumulative Percentage Frequency of Occurrence from Daily Observations, 1948-1977, Maximum Daily Temperatures, Annual Summary.

The "mean" temperature given in the cumulative daily temperature distributions is not really the mean. Since it is derived from daily observations, this "mean" is calculated as the average of the day's maximum and minimum or

$$\text{"mean"} = \frac{\text{maximum} + \text{minimum}}{2}$$

For days with what might be considered a normal temperature profile, this "mean" is an adequate approximation of the true mean. However, on days with a sudden temperature change brought about by, say, a frontal passage or chinook, this "mean" can be quite misleading. Since such sharp daily temperature changes are rare, overall, the daily "means" may be used with confidence. If, however, the true mean daily temperature for the month is required, the "Means and Standard Deviations" summaries based on hourly observations should be used. Indeed, the astute observer will note differences between the means given here and those in the "Means and Standard Deviation Summary."

The "Daily Temperatures" summaries give, in addition to monthly distributions of the temperatures, an annual summary, and, for each column, the mean, standard deviation, and observation count.

6.3 Extreme Values

As for the "Daily Temperatures" summaries, the "Extreme Values" summaries are based on daily observations. In these two summaries, Extreme Maximum Temperature (Figure 6.5) and Extreme Minimum Temperature (Figure 6.6), the monthly extremes are tabulated by year and month. Months where extremes are based on less than a full month's worth of data are indicated by an asterisk (*). Extremes from months in which at least one day had fewer than 24 hourly observations are indicated by a pound sign (#). An extreme is given for each month provided that the given month has at least one day with valid observations. All months of a year

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24006 ELLSWORTH AFB SD/RAPID CITY 48-77
STATION STATION NAME YEARS

DAILY TEMPERATURES

CUMULATIVE PERCENTAGE FREQUENCY OF OCCURRENCE
FROM DAILY OBSERVATIONS

MINIMUM

TEMP °F	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
≥ 80							.1						.0
≥ 75						.1	.6	.3	.1				.1
≥ 70						1.2	9.1	5.4	.4				1.3
≥ 65					.3	5.6	30.0	23.1	2.7				5.3
≥ 60				.1	2.8	23.9	65.4	55.4	10.9	.4			13.5
≥ 55				.6	9.7	52.2	89.2	82.3	27.8	3.5	.1		22.6
≥ 50				2.6	27.6	80.8	98.0	94.6	49.6	10.3	.2	.1	30.9
≥ 45	.1	.2	.9	10.2	51.7	94.9	99.9	99.2	71.4	26.1	1.1		38.6
≥ 40	.8	1.2	3.9	26.9	78.2	98.6	100.0	100.0	87.2	47.5	6.6	1.2	46.8
≥ 35	3.4	6.2	11.7	48.2	92.5	99.6			95.9	68.1	20.1	5.0	55.0
≥ 33	5.8	9.2	18.8	57.7	94.7	99.9			97.8	75.7	27.7	8.8	58.8
≥ 30	10.9	16.4	30.6	72.2	97.5	100.0			99.2	84.8	40.4	13.7	64.7
≥ 25	20.5	30.8	49.4	88.8	99.1				100.0	95.1	60.8	23.5	72.7
≥ 20	34.1	47.3	66.1	96.3	100.0					98.7	76.4	48.5	81.1
≥ 15	47.5	60.0	77.3	99.0						99.8	85.8	62.5	86.5
≥ 10	57.6	71.3	85.5	99.7						100.0	92.3	74.1	90.3
≥ 5	67.2	82.0	92.0	100.0							95.3	83.8	93.5
≥ 0	74.5	89.5	95.2								97.2	91.3	95.8
≥ -5	83.2	96.0	98.3								98.2	93.7	97.7
≥ -10	91.7	98.9	99.3								99.8	97.9	99.0
≥ -15	96.6	99.6	99.9								100.0	99.1	99.6
≥ -20	99.2	100.0	100.0									99.8	99.9
≥ -25	100.0											100.0	100.0
MEAN	11.3	16.9	22.4	34.1	45.0	54.8	61.4	59.9	49.2	38.7	25.7	17.3	36.4
S D	14.802	12.382	11.437	8.172	7.562	6.438	5.671	6.030	8.210	8.607	10.509	12.289	19.320
TOTAL OBS	899	818	899	900	930	900	930	930	900	930	[illegible]	[illegible]	10834

Figure 6.2. Cumulative Percentage Frequency of Occurrence from Daily Observations, 1948-1977, Minimum Daily Temperatures.

must have valid extremes before the annual extreme is selected. Means and standard deviation are computed for each month and for the annual summary provided that four or more values are in the specified column.

6.4 Bivariate Psychrometric Summaries

The summaries titled "Psychrometric Summary" are bivariate frequency distributions of dry-bulb temperatures with wet-bulb depression (see Figure 6.7). The numbers in the body of the summaries are the percentage frequencies of occurrence of a specified dry-bulb temperature with a specified wet-bulb depression. Both wet-bulb depressions and dry-bulb temperatures are given in 2°F intervals. A percentage frequency of "0.0" represents one or more occurrence, but less than 0.05%.

Given at the right of the summaries are total number of hours that had the specified dry-bulb temperature and some (any value) wet-bulb temperature, the total number of hours that had the specified dry-bulb temperature, the total numbers of hours that had the specified wet-bulb temperature, and the total number of hours that had the specified dew-point temperature. Differences between the first two columns (Total D.B./W.B. and Total Dry Bulb) arise from a reported dry-bulb temperature with no associated wet-bulb temperature.

At the bottom left of the last page of each discrete summary are statistical data pertinent to that summary. Given for the relative humidity, dry-bulb temperature, wet-bulb temperature, and the dew point are the sum of squares (Σx^2), the sum (Σx), the mean ($\bar{x}$) the standard deviation (σ_x), and the number of observations used. At bottom right on the page are the mean number of hours with dry-bulb temperatures in specified ranges. The total given with these data should equal the total number of hours per year or per month, or per 3-hour interval per month, as appropriate.

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DAILY TEMPERATURES

24006 ELLSWORTH AFB SD/RAPID CITY 48-77
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MEAN

CUMULATIVE PERCENTAGE FREQUENCY OF OCCURRENCE
(FROM DAILY OBSERVATIONS)

TEMP (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
≥ 90							.3						.0
≥ 85						.8	3.0	1.8	.3				.5
≥ 80					.1	2.9	19.0	15.6	1.7				3.4
≥ 75					.8	12.1	46.3	41.2	8.4	.3			9.3
≥ 70				.4	5.5	30.7	73.7	67.2	22.7	2.6			17.3
≥ 65				2.1	17.3	57.4	92.7	86.7	41.1	8.7	.1		26.0
≥ 60			.4	8.1	33.8	78.9	98.3	95.8	60.0	19.8	.4		33.5
≥ 55	.1	.6	2.6	18.7	56.3	95.7	99.6	99.7	76.6	35.7	3.2	.2	41.2
≥ 50	1.1	2.7	7.3	32.8	78.6	98.6	100.0	100.0	88.6	56.5	12.3	2.3	49.2
≥ 45	4.2	7.9	17.2	51.9	91.6	99.3			95.0	72.7	25.4	8.3	56.9
≥ 40	11.2	18.2	31.9	69.8	96.7	99.8			98.6	84.8	42.3	17.2	64.9
≥ 35	21.7	32.2	46.8	84.1	98.4	100.0			99.9	93.9	58.8	31.3	72.9
≥ 30	35.2	47.7	62.9	94.7	99.8				100.0	97.7	72.5	48.3	80.3
≥ 25	50.1	59.5	74.4	98.7	100.0					99.4	85.7	62.0	86.2
≥ 20	60.1	72.5	84.8	99.4						99.9	92.0	74.3	90.5
≥ 15	67.6	80.9	90.4	99.9						100.0	94.8	82.5	93.2
≥ 10	76.1	88.8	95.8	100.0							97.6	90.4	95.8
≥ 5	83.3	95.2	97.8								99.0	94.3	97.5
≥ 0	88.4	97.6	99.1								99.7	96.7	98.5
≥ -5	94.1	99.6	99.8								99.9	98.7	99.3
≥ -10	97.9	99.9	100.0								100.0	99.3	99.8
≥ -15	99.8	100.0										100.0	100.0
≥ -20	100.0												100.0
MEAN	21.6	27.1	32.6	45.1	56.0	65.8	73.6	72.5	61.6	50.6	34.2	27.3	47.5
S D	15.922	13.210	12.562	9.921	8.679	7.618	6.4[illegible]9	6.884	9.555	10.325	11.421	13.044	20.723
TOTAL OBS	899	818	899	900	930	900	[illegible]	930	900	930	899	899	10834

Figure 6.3. Cumulative Percentage Frequency of Occurrence from Daily Observations, 1948-1977, Mean Daily Temperatures.

Although the summaries contain data for wet-bulb temperature and depression, relative humidity, and dew point, it is important to realize that differing reporting procedures have had their effect on these moisture parameters. Before 1946 wet-bulb temperatures were not reported. From 1946 to about mid- 1971 wet-bulb temperature data were extracted by hand from station records. Since mid-1971 wet-bulb temperatures have been calculated from the reported dry-bulb and dew-point temperatures. Similarly relative humidity values have been calculated except for the period from about 1946 to June 1978 during which they were reported. All values of dew-point temperatures and relative humidity are with respect to liquid water unless others indicated.

6.5 Means and Standard Deviations

Three tabulations of means and standard deviations (see Figure 6.8) are given; one each for dry-bulb temperature, wet-bulb temperature, and dew point. These summaries are based on hourly as opposed to daily observations (hence 24 instead of one observation per day). These data are presented in eight 3-hour time blocks and for all hours by month and by year (annual summary). In addition to the means and standard deviations, the number of observations used is also given.

6.6 Relative Humidity

Cumulative percent frequencies of occurrence of relative humidity greater than specified values are given in two sets of summaries. Figure 6.9 is a sample of one of these summaries. These values are determined from hourly observations. The first summary is for all months, all hours combined. The second summary gives monthly tabulations broken out in three-hour increments.

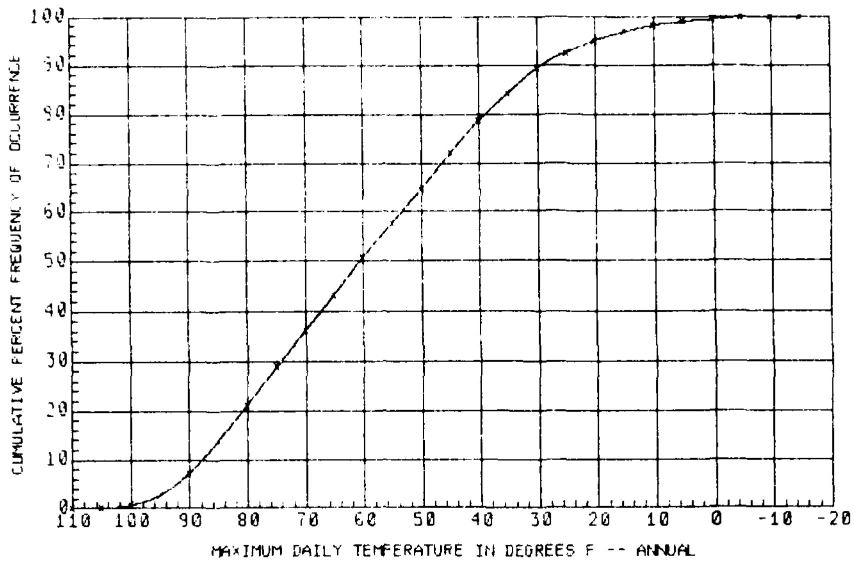

Figure 6.4. Cumulative Percentage Frequency of Occurrence, Maximum Daily Temperature, Annual Summary.

The relative humidities are given in 10 percent class intervals. Mean values of the relative humidity and the number of observations used in determining it are given at the right, and at bottom an overall total for the month or year.

6.7 Exercises for Temperatures, Dew Point, and Relative Humidity Summaries

Tables 6.1 through 6.8 contain sample questions and their solutions illustrating the uses of the various summaries in Part E of the RUSSWO. Most of the answers can be determined directly from the summaries; others may require ancillary data. These exercises are intended only to acquaint the user with the types of information that can be obtained from these data summaries. They are not intended to be comprehensive.

Table 6.1. Procedures for Determining Answers To Sample Questions from the Daily Maximum Temperature Summary (Figure 6.1, page 39). (All temperatures are in degrees Fahrenheit).

To Find	Pertinent Row/Column	Answer-
Mean daily maximum March temperature.	Mean/Mar	42.3°F
50th percentile of the daily maximum July temperature.	See Footnote 1	86.4°F
Mean number of June days when the daily maximum temperature is 90°F or more.	90/Jun	3[2]
Mean number of October days when the daily maximum temperature is 80°F or more.	80/Oct	3
Mean number of July days when the daily maximum temperature is 78°F or more.	75/80/July	25[3]
Standard deviation of the daily maximum September temperature.	S.D./Sep	12.378[4]
Mean annual daily maximum temperature.	Mean/Annual	58.2°F

DATA PROCESSING BRANCH
USAF/ETAC/DL A
AIR WEATHER SERVICE/MAC

EXTREME VALUES

MAXIMUM TEMPERATURE

(FROM DAILY OBSERVATIONS)

24005 (STATION) ELLSWORTH AFB SD/RAPID CITY (STATION NAME) 48-77 (YEARS)

WHOLE DEGREES FAHRENHEIT

YEAR \ MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL MONTHS
48				84	94	89	100	102	102	83	62	56	
49	54	52	56	83	86	97	104	104	93	89	72	59	104
50	53	62	66	74	85	99	95	95	92	83	65	58	99
51	53	71	65	63	89	84	102	94	82	84	65	66	102
52	56	63	57	86	89	101	108	97	96	87	76	65	108
53	67	54	64	79	82	92	93	100	89	93	75	59	100
54	63	72	71	79	89	99	106	100	91	86	73	57	106
55	60	53	65	84	89	97	99	99	97	89	73	65	99
56	61	64	78	78	83	99	97	92	90	88	57	62	99
57	44	63	67	73	84	86	97	97	88	87	64	71	97
58	63	68	66	83	87	99	90	100	94	85	71	65	100
59	58	54	66	84	85	96	97	100	102	75	72	63	102
60	61	63	76	84	88	95	102	101	103	85	74	64	103
61	59	69	75	81	89	105	100	103	92	83	68	60	105
62	60	71	70	86	83	9[illegible]	89	98	93	82	69	62	9[illegible]
63	60	64	80	81	88	94	99	93	96	94	70	64	99
64	59	57	72	77	89	92	100	99	93	70	73	62	100
65	60	65	58	79	87	81	98	99	90	87	74	73	99
66	61	47	75	72	88	103	109	95	94	84	69	64	109
67	62	64	82	74	84	84	96	98	91	85	70	59	9[illegible]
68	66	58	73	79	77	93	95	96	91	84	64	60	96
69	55	54	71	81	97	95	99	105	94	83	73	70	105
70	60	66	66	80	85	93	96	100	97	85	64	57	100
71	51	50	70	82	79	92	96	100	102	79	70	59	102
72	61	67	81	73	85	89	96	99	94	81	60	54	99
73	65*	60	63	74	86	91	111	102	88	82	68	70	111
74	68	61	73	82	82	104	100	100	92	87	70	60	1[illegible]6
75	50	48	61	79	87	89	104	107	87	92	73	56	107
76	56	64	64	78	88	9[illegible]	98	101	101	89#	71	59	101
77	43	63	68	82	84	94	103	94	91	81	69		
MEAN	58.2	61.0	68.9	79.9	86.3	93.6	99.3	99.2	93.5	84.5	69.4	63.1	101.6
S D	6.075	7.115	6.928	4.021	3.947	5.162	5.114	3.343	4.960	4.137	4.136	4.257	3.035
TOTAL OBS	899	818	899	900	930	900	930	930	900	930	899	899	10634

NOTES * (BASED ON LESS THAN FULL MONTHS)
(AT LEAST ONE DAY LESS THAN 24 OBS)

Figure 6.5. Extreme Values of Maximum Temperature in Whole Degrees Fahrenheit, 1948-1977.

Table 6.1 - Continued

To Find	Pertinent Row/Column	Answer
Mean number of days per year when the daily maximum temperature is greater than 49°F.	50/Annual	237
Month with the highest mean daily maximum temperature.	Mean/Jul	Jul

[1] There are several ways to answer this question. The simplest is to assume (usually falsely) that the temperatures are normally distributed. Thus, the 50th percentile is the same as the mean, and the mean is given at the bottom of the table (in this case 85.4°F). In fact, the 50th percentile is the median value or that value above and below which half the observations lie. Only in a normal distribution are the mean and medium equal. If the distribution is skewed they are not equal. A second method is to linearly interpolate between the 33.5 percent and 57.0 percent (90°F and 85°F) values to obtain the temperature equalled or exceeded 50 percent of the time. This technique gives an answer of 86.5°F. A third method is to construct the appropriate ogive (the 'S' shaped cumulative frequency curve of Figure 6.10) and read from the graph the 50th percentile value (86.4°F). This last is probably the most accurate method since it makes the fewest assumptions about the distribution of temperature (it does not assume a normal distribution nor does it assume linearity between neighboring points on the curve). Also, once drawn, the curve can quickly give other percentiles as well:

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EXTREME VALUES

MINIMUM TEMPERATURE

(FROM DAILY OBSERVATIONS)

24006 ELLSWORTH AFB SD/RAPID CITY 48-77
STATION STATION NAME YEARS

WHOLE DEGREES FAHRENHEIT

MONTH / YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL MONTHS
48				21	32	44	53	51	42	19	15	2	
49	-25	-11	-3	20	35	45	54	48	32	22	15	-2	-25
50	-24	-4	-14	13	21	42	45	48	32	29	0	-7	-24
51	-19	-11	-10	16	35	31	48	49	27	14	2	-15	-19
52	-16	1	-2	21	32	49	48	50	41	21	2	11	-16
53	-8	-2	5	19	23	44	53	51	36	27	17	4	-9
54	-15	11	-1	13	20	34	54	54	35	21	15	9	-15
55	-2	-6	-6	25	39	43	56	50	33	29	-7	-9	-9
56	-6	-10	-7	15	29	49	54	48	39	27	12	-8	-10
57	-20	-8	0	12	38	49	55	49	31	20	18	9	-20
58	13	-4	13	24	39	37	50	48	32	29	5	-8	-8
59	-15	-4	17	17	32	43	42	52	29	21	-14	9	-15
60	-6	-8	-11	25	34	45	55	48	36	15	7	-3	-11
61	-8	7	21	21	32	49	55	55	27	24	13	-8	-8
62	-14	-18	-18	21	35	41	50	44	32	21	19	-4	-18
63	-23	-10	12	25	26	50	52	50	39	22	9	-14	-23
64	-10	-8	0	16	35	39	54	41	30	26	-3	-22	-22
65	-4	-13	-10	19	33	45	53	46	29	31	14	-2	-13
66	-22	-12	3	6	29	41	56	44	37	25	2	1	-22
67	-2	-5	-1	19	24	42	47	49	28	22	7	-18	-18
68	-19	-3	5	10	27	43	47	44	36	20	12	-21	-21
69	-15	3	-1	24	35	33	51	54	42	15	12	3	-15
70	-13	8	6	19	33	43	52	53	33	19	4	-11	-13
71	-9	-20	8	25	34	49	45	50	33	17	11	-2	-20
72	-21	-7	2	20	33	39	45	50	25	13	16	-19	-21
73	-13*	-3	22	16	32	44	51	56	34	24	3	-13	-13
74	-17	0	2	21	35	40	53	48	30	28	6	7	-17
75	-7	-16	3	5	36	43	52	48	33	23	-4	-7	-16
76	-16	-7	-6	27	23	40	53	47	33	17#	-10	-4	-16
77	-14	10	15	21	38	51	51	47	42	27	-10		
MEAN	-12.8	-5.3	1.5	18.5	31.6	42.[illegible]	51.1	49.1	33.5	22.3	6.8	-4.9	-16.4
S D	8.206	7.980	10.070	5.544	5.308	4.994	3.702	3.403	4.661	4.744	8.698	9.319	5.292
TOTAL OBS.	899	818	899	900	930	900	930	930	900	930	899	899	10834

NOTES * (BASED ON LESS THAN FULL MONTHS)
(AT LEAST ONE DAY LESS THAN 24 OBS)

Figure 6.6. Extreme Values of Minimum Temperature in Whole Degrees Fahrenheit, 1948-1977.

10th percentile = 96°F (i.e., 10 percent of the maximum temperatures will equal or exceed 96°F), 25th percentile = 92°F.

[2] Ordinarily, the percent of time that a phenomenon occurs cannot be readily converted into the mean number of days. In the case of this summary, only one maximum temperature is observed per day and as a result, the conversion can be made. The above answer is found by multiplying the percent of time that the temperature is 90 or greater (8.7 percent) by the number of days in June (30) and rounding to the nearest whole number (0.87 x 30 = 2.61 or 3 days).

[3] The pertinent percentage (81.7) may be interpolated from the table or preferably obtained from the appropriate ogive (82.5 from Figure 6.3). See Footnote 1 for further discussion. This percentage is then multiplied by 31 days in July to determine the number of days when the daily maximum temperture is 78°F or more.

[4] The standard deviation is a measure of the deviation of individual numbers of a given distribution from the mean of the distribution. For a normal or Gaussian distribution, 68 percent of the numbers are included between the mean minus one standard deviation and the mean plus one standard deviation. Extreme values cannot usually be described by a normal distribution, and as a result, the aforementioned percentage does not apply, but the standard deviation is still a useful tool in working with extreme values. For additional material, refer to Gringorten (1960).

Table 6.2. Procedures for Determining Answers To Sample Questions from the Daily Minimum Temperature Summary (Figure 6.2, page 40). (All temperatures are in degrees Fahrenheit.)

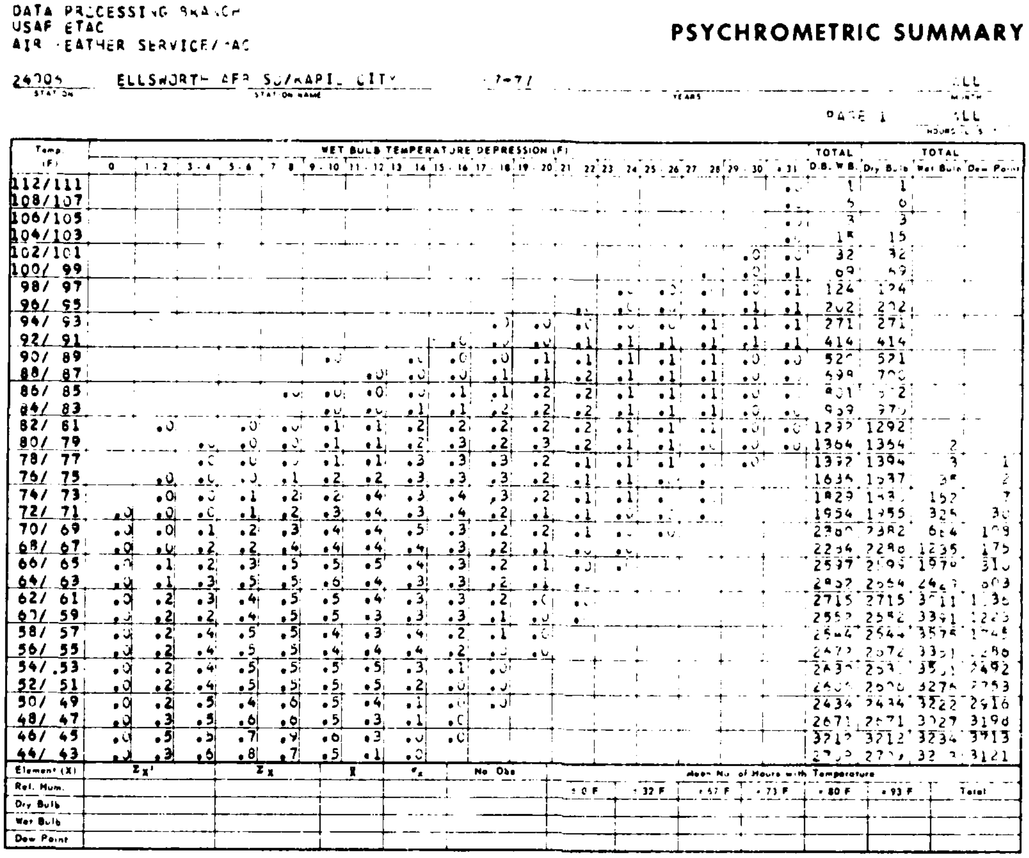

Figure 6.7. Psychrometric Summary, 1967-1977, All-Hours, All-Months.

Table 6.2 - Continued

To Find	Pertinent Row/Column	Answer
Standard deviation of the annual daily minimum temperature.	S.D/Annual	19.520[1]
Highest and lowest standard deviation of the daily minimum temperature.	S.D./Jan and Jul	14.802/ 5.671
Mean daily minimum October temperature.	Mean/Oct	38.7°F
Months with the highest and lowest daily minimum temperatures.	Mean/Jul and Jan	Jul(61.4°F) Jan(11.3°F)
Values of the April daily minimum temperatures spanning the 16th through the 84th percentile.	See Footnote 2	26.4°F/ 43.3°F
Mean annual daily minimum temperature.	Mean/Annual	36.4°F
Mean number of August days when the daily minimum temperature is less than 60°F.	60/Aug	14[3]
Mean number of January days with daily minimum temperatures of 32°F or less.	33/Jan	29[4]

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PSYCHROMETRIC SUMMARY

24[illegible] ELLSWORTH AFB SD/RAPID CITY [illegible]7-77 ALL

STATION — STATION NAME — YEARS — MONTH

PAGE 2 ALL

HOURS (L.S.T.)

Temp (F)	0	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30	≥31	TOTAL D.B. / W.B.	TOTAL Dry Bulb	TOTAL Wet Bulb	TOTAL Dew Point
42/ 41	.0	.3	.6	.7	.6	.4	.1	.0										2467	2467	3223	2928
40/ 39	.0	.5	.9	1.0	.3	.2	.0											3044	3044	3372	2743
38/ 37	.1	.5	1.0	1.1	.5	.1	.0											2991	2991	3548	2613
36/ 35	.1	.6	.9	1.1	.4	[illegible]	.0											2745	2745	[illegible]	2996
34/ 33	.1	.6	1.2	1.0	.3	.0												2903	2905	3729	3043
32/ 31	.1	.8	1.2	.7	.1	.0												2553	2557	3911	3277
30/ 29	.1	1.2	1.2	.5	.0													2639	2639	3690	3809
28/ 27	.2	1.3	1.1	.3	.0													2578	2579	3649	4298
26/ 25	.2	1.1	.9	.2	.0													2096	2099	2928	4243
24/ 23	.1	1.0	.5	.1														1448	1448	2413	3549
22/ 21	.1	1.0	.5	.0														1472	1472	1955	4000
20/ 19	.1	1.1	.3	.0														1424	1426	1595	3684
18/ 17	.1	.9	.2	.0														1164	1169	1520	3182
16/ 15	.2	.8	.1	.0														1010	1014	1407	2998
14/ 13	.2	.7	.1															826	831	949	2166
12/ 11	.2	.7	.1															856	866	918	1990
10/ 9	.2	.9	.0															1035	1038	920	1982
8/ 7	.1	.7	.0															711	716	870	1383
6/ 5	.1	.5	.0															550	558	702	1033
4/ 3	.1	.5																517	517	520	819
2/ 1	.0	.4																377	377	439	770
0/ -1	.2	.1																323	323	477	621
-2/ -3	.1	.3																342	342	352	547
-4/ -5	.1	.1																203	203	244	440
-6/ -7	.1	.1																198	198	207	397
-8/ -9	.2	.0																252	252	264	430
-10/-11	.1	.0																141	141	145	323
-12/-13	.1	.0																81	81	85	249
-14/-15	.1	.0																87	87	91	273
-16/-17	.0																	41	41	41	224
-18/-19	.0	.0																16	16	16	192
-20/-21	.0																	12	12	12	149
-22/-23																					95
-24/-25																					131

Element (X)	Σx^2	Σx	$\bar{x}$	σ_x	No. Obs.	Mean No. of Hours with Temperature ≤ 0 F	≤ 32 F	≥ 67 F	≥ 73 F	≥ 80 F	≥ 93 F	Total
Rel Hum												
Dry Bulb												
Wet Bulb												
Dew Point												

Figure 6.7. Psychometric Summary (Cont'd).

1 See Footnote 4, Table 6.1.

2 The most direct and accurate way to answer this question would be to plot the ogive and then read off the appropriate limits. An alternative is to linearly extrapolate to the specified percentile (in this case giving a temperature range of 26.4°F-43.3°F). A third method would be to realize that the specified range of the 16th-84th percentiles is 68 percent and that for a normal (i.e., Gaussian) distribution the mean plus and minus one standard deviation includes 68 percent of the values. Thus, we may assume a normal distribution and use the mean (34.1) and the standard deviation (8.172) to arrive at the temperature range 25.9-42.3°F. Because of the various errors involved and assumptions required, regardless of method, rounding to the nearest whole degree is suggested.

3 Reference Footnote 2, Table 6.1. Also observe that the percentage in the block (55.4) must be subtracted from 100.0 to determine the percentage of time temperature less than 60°F occurs.

4 We assume only integer values for temperature. Thus, the appropriate temperature row is "≥ 32," which is to say that if 5.8 percent of the January minimum temperatures equal or exceed 33°F then 100 - 5.8 = 94.2 percent of the minimum temperatures must be 32°F or colder. Hence, 0.942 x 31 = 29.2 days or, rounding, 29 days on average can be expected to have a minimum temperature ≤ 32°F in January.

Table 6.3. Procedures for Determining Answers To Sample Questions from the Daily Mean Temperature Summary (Figure 6.3, page 41). (All temperatures are in degrees Fahrenheit.)

DATA PROCESSING BRANCH
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PSYCHROMETRIC SUMMARY

24006 ELLSWORTH AFB SD/RAPID CITY 67-77 (YEARS) ALL (MONTH)
STATION / STATION NAME

PAGE 3 ALL (HOURS (L. S. T.))

Temp (F)	0	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30	≥31	TOTAL D.B./W.B.	TOTAL Dry Bulb	TOTAL Wet Bulb	TOTAL Dew Point
-25/-27																					45
-28/-29																					11
-30/-31																					9
-32/-33																					1
TOTAL	3.9	20.0	15.9	13.0	11.[illegible]	6.5	6.7	5.4	4.3	3.1	2.3	1.7	1.2	.9	.6	.4	.6	87564	87634	87564	87564

Element (X)	Σx^2	Σx	$\bar{X}$	σ_x	No. Obs.	Mean No. of Hours with Temperature ≤0 F	≤32 F	≥67 F	≥73 F	≥80 F	≥93 F	Total
Rel. Hum.	321703916	5030476	57.4	19.329	87564							
Dry Bulb	237197955	4130096	47.1	22.021	87634	169.4	2297.0	1828.1	1145.3	602.2	72.3	8760
Wet Bulb	162403765	3454679	39.5	17.241	87564	193.5	3031.6	244.0	19.2			8760
Dew Point	110674282	2707774	30.9	17.541	87564	413.8	4732.0	32.3	1.0			8760

Figure 6.7. Psychrometric Summary (Cont'd).

Table 6.3 - Continued

To Find	Pertinent Row/Column	Answer
Mean daily temperature in May.	Mean/May	56.0°F[1]
Daily mean December temperature.	Mean/Dec	27.3°F
Standard deviation of the daily mean November temperature.	S.D./Nov	11.621[2]
Mean number of July days with daily mean temperature greater than 79°F.	80/Jul	6[3]
Mean number of February days with daily mean temperature less than 45°F.	45/Feb	26[4]
Daily mean June temperature which is exceeded 90 percent of the time.	55/Jun and 60/Jun	56°F[5]
Daily mean September temperature which is exceeded 10 percent of the time.	70/Sep and 75/Sep	74°F[6]
Highest monthly daily mean temperature.	Mean/July	73.6°F
Next to the lowest monthly daily mean temperature.	Mean/Feb	27.1°F
Mean annual number of days with daily mean temperature less than 35°F.	35/Annual	99[7]

DATA PROCESSING BRANCH
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MEANS AND STANDARD DEVIATIONS

[illegible]

24006 ELLSWORTH AFB SD/RAPID CITY [illegible]

HRS (LST)		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
	MEAN	7.3	14.2	18.5	28.2	[illegible]	[illegible]	51.2	49.2	[illegible]	29.[illegible]	[illegible]	12.7	[illegible]
00-02	S.D.	15.34[illegible]	1[illegible].492	9.718	9.315	8.451	7.84	6.914	7.437	8.667	7.492	9.353	11.56	17.531
	TOTAL OBS	930	843	930	900	93[illegible]	[illegible]	927	927	[illegible]	[illegible]	897	[illegible]	[illegible]
	MEAN	7.2	13.6	17.6	27.5	37.3	[illegible]	[illegible]	48.7	39.[illegible]	2[illegible]	19.9	12.4	2[illegible].1
03-05	S.D.	15.335	1[illegible].726	8.918	9.3[illegible]	9.44[illegible]	7.699	6.775	7.412	8.514	7.35[illegible]	9.329	11.5[illegible]4	17.491
	TOTAL OBS	93[illegible]	846	930	900	929	[illegible]	927	93[illegible]	[illegible]	93[illegible]	[illegible]	92[illegible]	[illegible]
	MEAN	6.9	13.4	18.2	29.1	40.4	49.6	52.8	50.3	[illegible]	29.[illegible]	18.9	12.4	[illegible]
06-08	S.D.	15.141	10.76[illegible]	9.065	9.046	7.885	7.242	6.424	7.473	8.43[illegible]	7.295	9.513	11.757	1[illegible].232
	TOTAL OBS	922	844	929	900	929	[illegible]	927	93[illegible]	[illegible]	[illegible]	899	92[illegible]	[illegible]
	MEAN	9.5	15.4	20.3	30.3	41.4	5[illegible].7	53.7	51.4	41.2	3[illegible]	21.4	14.9	[illegible]1.9
09-11	S.D.	14.864	10.295	8.465	9.263	[illegible].282	[illegible]	7.232	9.229	8.481	7.253	9.420	11.575	17.[illegible]
	TOTAL OBS	927	847	929	900	930	[illegible]	928	93[illegible]	[illegible]	93[illegible]	900	92[illegible]	[illegible]
	MEAN	11.3	19.[illegible]	21.2	30.5	41.5	51.1	53.4	50.7	4[illegible].7	31.[illegible]	21.4	16.[illegible]	32.4
12-14	S.D.	14.417	9.459	8.410	8.994	9.302	[illegible].362	7.214	8.27[illegible]	8.635	7.40[illegible]	9.150	11.214	17.[illegible]12
	TOTAL OBS	929	847	930	900	930	[illegible]	930	93[illegible]	[illegible]	[illegible]	900	[illegible]	[illegible]
	MEAN	11.4	19.3	20.[illegible]	30.4	41.4	[illegible]	52.8	49.7	4[illegible].1	3[illegible].7	21.3	15.4	[illegible]
15-17	S.D.	14.583	9.635	8.599	8.845	[illegible].366	[illegible].283	7.158	8.193	[illegible].213	7.545	9.229	11.33[illegible]	[illegible]
	TOTAL OBS	929	846	930	900	930	[illegible]	927	927	[illegible]	92[illegible]	899	927	[illegible]
	MEAN	9.3	16.9	20.2	30.2	41.4	[illegible]1.1	53.0	49.[illegible]	39.[illegible]	30.[illegible]	20.4	14.[illegible]	[illegible]1.4
18-20	S.D.	14.858	10.012	8.571	8.872	[illegible].313	7.794	7.188	8.144	8.675	7.61[illegible]	9.364	11.497	17.554
	TOTAL OBS	930	848	930	900	930	[illegible]	927	92[illegible]	900	93[illegible]	897	927	[illegible]
	MEAN	8.5	15.3	19.5	29.5	40.2	49.3	52.2	49.3	39.7	29.5	19.9	13.2	[illegible]
21-23	S.D.	14.784	10.080	8.635	9.013	8.201	7.35[illegible]	7.033	7.703	8.656	7.50[illegible]	9.312	11.717	17.497
	TOTAL OBS	930	846	930	900	929	[illegible]	926	927	900	93[illegible]	896	9[illegible]	[illegible]
	MEAN	9.1	15.8	19.5	29.5	40.4	49.7	52.5	49.9	4[illegible].1	29.[illegible]	20.2	13.9	[illegible]
ALL HOURS	S.D.	15.008	10.346	8.755	9.138	8.379	7.967	7.066	7.908	8.639	7.594	9.366	11.6[illegible]7	17.541
	TOTAL OBS	7433	6767	7438	7200	7437	719[illegible]	7419	743	7200	743[illegible]	7188	7415	[illegible]

Figure 6.8. Means and Standard Deviations for Dew-Point Temperatures in Degrees Fahrenheit from Hourly Observations, 1967-1977.

Table 6.3 - Continued

To Find	Pertinent Row/Column	Answer
Mean number of days in March with daily mean temperature of 50°F or more.	50/Mar	2[8]

[1] If the daily mean temperature is needed, the "MEANS AND STANDARD DEVIATIONS" summary of dry-bulb temperature since for this summary hourly observations are used, instead of "DAILY TEMPERATURES" where only "daily observations" are used. Indeed, this summary (DAILY TEMPERATURES - MEAN) should be used only for determining the distributions of the means and for determining "the number of days with. . ."

[2] See Footnote 1, Table 6.1. Also, the comments of Footnote 1 above apply here as well.

[3] Ordinarily, the percentage of time that a phenomenon occurs cannot be readily converted into the mean number of days. In the case of this summary, only one mean temperature is observed per day and as a result, the conversion can be made. The above answer is found by multiplying the percentage of time that the temperatures greater than 79°F occur (19.0) by the number of days in July (31) and rounding to the nearest whole number. Here, we assume that the mean temperature can assume only integer values so that saying > 79 is equivant to saying ≥ 80.

[4] (1 - 0.079) x 28 = 25.788 or 26 days.

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RELATIVE HUMIDITY

STATION	STATION NAME	PERIOD	MONTH
24006	ELLSWORTH AFB SD/RAPID CITY	67-77	ALL

CUMULATIVE PERCENTAGE FREQUENCY OF OCCURRENCE
(FROM HOURLY OBSERVATIONS)

MONTH	HOURS (LST)	PERCENTAGE FREQUENCY OF RELATIVE HUMIDITY GREATER THAN									MEAN RELATIVE HUMIDITY	TOTAL NO OF OBS
		10%	20%	30%	40%	50%	60%	70%	80%	90%		
JAN	ALL	100.0	99.8	97.9	92.7	78.9	54.5	30.0	11.7	2.7	62.4	7433
FEB		100.0	99.3	95.5	87.8	74.5	56.9	35.2	13.6	2.9	62.2	6767
MAR		100.0	97.5	90.6	70.9	68.1	51.9	33.3	15.1	2.6	59.5	7438
APR		99.9	97.2	89.1	77.2	62.3	46.9	32.9	19.2	5.9	58.7	7200
MAY		100.0	99.4	93.5	79.8	65.2	48.8	32.6	16.6	5.6	59.8	7437
JUN		100.0	99.3	94.5	82.0	66.0	45.6	28.3	12.9	3.9	58.9	7198
JUL		100.0	97.3	86.1	69.3	49.2	30.9	15.7	6.1	1.6	51.3	7419
AUG		100.0	94.9	81.0	63.0	44.1	27.8	15.7	7.1	2.3	49.3	7430
SEP		99.9	94.6	82.6	65.8	47.6	31.2	18.2	5.9	1.0	50.3	7200
OCT		100.0	96.1	85.0	70.3	54.0	38.2	24.7	11.3	3.1	54.0	7438
NOV		100.0	98.8	92.6	80.1	63.5	46.9	32.0	19.2	5.1	59.3	7188
DEC		100.0	99.5	97.3	91.0	79.[illegible]	60.0	35.9	17.5	4.7	64.1	7416
TOTALS		100.0	97.5	90.5	79.2	62.[illegible]	45.0	27.9	13.0	3.5	57.5	87564

Figure 6.9. Cumulative Frequency of Occurrence from Hourly Observations, 1967-1977, Relative Humidity, All-Months.

5 The correct solution is that temperature associated with the 90th cumulative percentage frequency which must be interpolated from the summary. Linear interpolation is adequate, but plotting the ogive would give a more exact answer (see Footnote 1, Table 6.1).

6 The answer is found by interpolating for the temperature value at the 10th cumulative percentage frequency (see Footnote 5 above).

7 (1 - 0.729) x 365 = 98.915 or 99 days.

8 31 x 0.073 = 2.263 or 2 days.

Table 6.4. Procedures for Determining Answers To Sample Questions from the Extreme Value Maximum Temperature Summary (Figure 6.5, page 43). (All temperatures are degrees Fahrenheit.)

To Find	Pertinent Row/Column	Answer
Extreme maximum temperature in April 1948.	48/Apr	84°F
Extreme maximum temperature in November 1963.	63/Nov	70°F
Extreme all-years June maximum temperature.	74/Jun	106°F
Extreme all-years October maximum temperature	63/Oct	94°F
Highest temperature ever observed during 1952 through 1975.	73/Jul or 73/All-Months	111°F

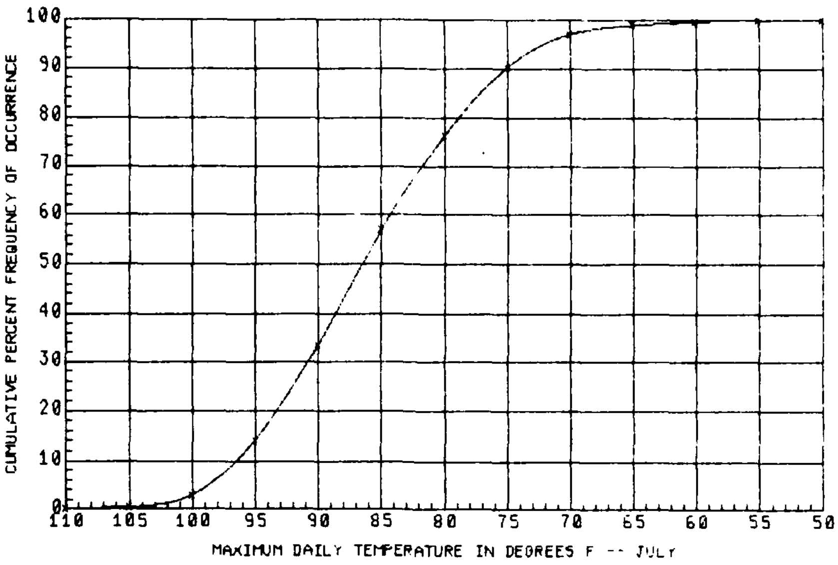

Figure 6.10. Cumulative Percentage Frequency of Occurrence, Maximum Daily Temperature in Degrees Fahrenheit, July Summary.

Table 6.4 - Continued

To Find	Pertinent Row/Column	Answer
Extreme maximum temperature recorded in 1975.	75/Aug or 75/All-Months	107°F
Standard deviation of the extreme maximum temperature in October.	S.D./Oct	4.132[1]
Highest monthly mean of the extreme maximum temperature.	Mean/Jul	99.3°F
Lowest monthly mean of the extreme maximum temperature.	Mean/Jan	58.2°F
Highest standard deviation of the monthly extreme maximum temperature.	S.D./Feb	7.115
Lowest standard deviation of the monthly extreme maximum temperature.	S.D./Aug	3.343
Mean annual extreme maximum temperature.	Mean/All-Months	101.6°F
Range over which 68 percent of the annual extreme temperatures can be expected to occur.	Mean and SD/All-Months	98-105°F[2]

[1] See Footnote 1, Table 6.1.

[2] Recall that 68 percent of the values in a normally distributed sample will fall between the mean minus one standard deviation and the mean plus one standard deviation. We assume a normal distribution.

Table 6.5. Procedures for Determining Answers To Sample Questions from the Extreme Value Minimum Temperature Summary (Figure 6.6, page 44). (All temperatures are in degrees Fahrenheit.)

To Find	Pertinent Row/Column	Answer
Extreme minimum temperature in March 1949.	49/Mar	-3°F
Extreme minimum temperature in September 1952.	52/Sep	41°F
Extreme all-years May minimum temperature.	54/May	20°F
Extreme all-years minimum temperature for November.	59/Nov	-14°F
Lowest temperature ever observed from 1952 through 1975.	63/Jan or 63/All-Months	-23°F
Extreme minimum temperature recorded in 1971.	71/Feb or 71/All-Months	-20°F
Extreme minimum temperature recorded in 1976..	76/Jan or 76/All-Months	-16°F
Extreme minimum temperature recorded in 1949.	49/Jan or 49/All-Months	-25°F
Standard deviation of the mean extreme minimum January temperature.	S.D./Jan	8.206[1]
Mean annual extreme minimum.	Mean/All-Months	-16.4°F
Month with the highest monthly mean of the extreme minimum temperature.	Mean/Jul	Jul
Month with the lowest monthly mean of the extreme minimum temperature.	Mean/Jan	Jan
Largest standard deviation of the mean monthly extreme minimum temperature.	S.D./Mar	10.070
Smallest standard deviation of the mean monthly extreme minimum temperature.	S.D./Aug	3.403

[1] See Footnote 1, Table 6.1.

Table 6.6. Procedures for Determining Answers To Sample Questions from the All-Months Psychrometric Summary (Figure 6.7, page 45). (All temperatures are in degrees Fahrenheit.)

To Find	Pertinent Row/Column	Answer
Mean annual number of hours with dry-bulb temperature (air temperature) of 93°F or more.	Dry Bulb/Mean No. of Hours with Temperature	72.3[1]

Table 6.6 - Continued

To Find	Pertinent Row/Column	Answer
Mean annual number of hours with wet-bulb temperature 32°F or less.	Wet Bulb/Mean No. of Hours with Temperature	3031.6[2]
Mean annual number of hours with the dew-point temperature of 73°F or more.	Dew Point/Mean No. of Hours with Temperature	1.0
Mean annual percentage of time dry-bulb temperature of 79 or 80°F (80/79) and wet-bulb depression of 13-14.	80/79 / 13-14	0.2
Mean annual percentage of time with dry-bulb temperature 74/73 and wet-bulb depressions of 15-16.	74/73 / 15-16	0.4
The total number of dry-bulb temperatures 88/87 for which wet-bulb temperatures were simultaneously reported.	Total D.B./W.B.	698[3]
Total number of dry-bulb temperatures reported in the 88/87 range.	88/87 / Dry Bulb	700[4]
Mean annual percentage of time with wet-bulb depressions of 1-2.	Total/1-2	20.0
Mean annual percentage of time with dry-bulb temperature 72/71 and wet-bulb depressions of 0.	72/71	0.0[5]
Mean annual percentage of time with dry-bulb temperatures 46/45 and wet-bulb depressions of 0-10.	46/45 / 0-10	3.2
Mean annual percentage of time with wet-bulb depressions of 1-4.	Total/1-4	35.9
Total number of dry-bulb and total number of wet-bulb temperature observations.	Total/Total (Dry Bulb and Wet Bulb)	87634 87564
Mean annual number of hours with dry-bulb temperatures of 73° or greater.	Dry Bulb/Mean No. of Hours with Temperature	1165.3
Mean annual dry-bulb temperature.	Dry Bulb/ $\bar{x}$	47.1[6]
Standard deviation of the wet-bulb temperature.	Wet Bulb/ σ_x	17.261[7]
Mean annual dew-point temperature.	Dew Point/ $\bar{x}$	30.9
Mean annual relative humidity.	Rel. Hum./ $\bar{x}$	57.4

[1] If this value had not already been calculated, it could be found by summing up the number of hours that had a dry-bulb temperature of 93°F or greater, dividing by the total number of dry-bulb temperatures observed and multiplying by the number of hours in a year. This methodology must be followed to find, for instance, the number of hours per year with temperature between 95 and 100°F (Answer: ((202 + 124 + 69)/87634)x(365.25x24) = 39.51 or 40 hours).

[2] The wet-bulb temperature is determined by wetting the muslin covering around the base of the wet-bulb thermometer, expediting the evaporation of the water from the muslin by whirling the thermometer, ventilating it, etc., and reading the resulting temperature. The values of the air pressure and wet-bulb depression (dry-bulb minus wet-bulb temperatures) are used with look-up tables to obtain the dew-point temperature, vapor pressure, and relative humidity. For more information, refer to Marvin (1941).

[3] Wet-bulb temperatures were usually not reported before 1946; therefore, it is often desirable to know how many dry-bulb temperatures for a given range, e.g., 88/87 were accompanied by simultaneously observed wet-bulb temperatures. The 'Total D.B/W.B.' block permits this information to be determined.

[4] From this and the preceding exercise, it is concluded that two observations in the 88/87 dry-bulb temperature range lacked associated wet-bulb temperatures.

[5] The answer of 0.0 means that some observations occurred in the range considered but this amounted to less than 0.05 percent. For those blocks with no entries, no values in those categories were ever observed during the period of record (1967-1977).

[6] This temperature (47.1°F) should be the same as that listed for the annual mean temperature (47.5°F) in the daily mean temperature summary (Figure 6.5). The numerical difference between the two is due to the method of computation. The dry-bulb temperature in this section is calculated from the expression where $\bar{x}$ is the mean, Σx is the sum of all the temperatures, and N is the total number of temperatures observed. The mean from Figure 6.1 was based not on all hourly observations but on "daily observations" of the maximum and minimum temperatures (mean = (max + min)/2). The mean value of 47.1 given here is identical with that from the "Means and Standard Deviations" summary.

[7] The standard deviation is a measure of the deviation of individual numbers of a given distribution from the mean of the distribution. For a normal or Gaussian distribution, 68 percent of the numbers are included between the mean minus one standard deviation and the mean plus one standard deviation. The standard deviation (σ_x) can be calculated from the expression $\sigma_x = ((\Sigma x^2/N)-(\Sigma x/N)^2)^{\frac{1}{2}}$. The statistical terms Σx^2, Σx, and N are all included in this summary.

Table 6.7. Procedures for Determining Answers To Sample Questions from the Dew-Point Temperature (Means and Standard Deviations) Summary (Figure 6.8, page 48). (All temperatures are in degrees Fahrenheit.)

To Find	Pertinent Row/Column	Answer
Mean May dew-point temperature during 12-14 LST.	12-14 (Mean)/ May	41.5°F
Mean January dew-point temperature.	All-Hours (Mean)/Jan	9.1°F
Mean annual dew-point temperature during 06-08 LST.	06-08 (Mean)/ Annual	30.2°F
Standard deviation of the August dew-point temperature during 21-23 LST.	21-23 (S.D.)/Aug	7.703
Highest and lowest mean April dew-point temperature during a standard 3-hourly interval.	12-14 (Mean)/Apr 03-05 (Mean)/Apr	30.5°F 27.5°F
Greatest 3-hourly standard deviation of the September dew-point temperature.	15-17(S.D.)/Sep	8.813
Lowest mean annual 3-hourly dew-point temperature.	03-05(Mean)/Ann	29.1°F

Table 6.7 - Continued

To Find	Pertinent Row/Column	Answer
Standard deviation of the June dew-point temperature.	All-Hours (S.D.)/ Jun	7.963
Values of the 16th and 84th percentiles of the 15-17 LST December dew-point temperature.	15-17 Mean and S.D./Dec	4.1°F 26.7°F
The 99.95th percentile lowest July dew-point temperature.	All-Hours Mean and S.D./Jul	29.3°F[3]
The 99.95th percentile highest November dew point.	All-Hours Mean and S.D./Nov	51.1°F
Greatest 3-hourly standard deviation of the dew-point temperature.	00-02(S.D.)/Jan	15.340

[1] The standard deviation is a measure of the deviation of individual numbers of a given distribution from the mean of the distribution. For a normal or Gaussian distribution, 68 percent of the numbers are included between the mean minus one standard deviation and the mean plus one standard deviation.

[2] The required values are obtained by adding to and subtracting from the mean one standard deviation. The dew-point temperature distribution can be assumed to be almost normal (Gaussian).

[3] In a normal distribution the 0.05th percentile lowest value is determined by multiplying the standard deviation (7.066) by 3.29 and subtracting the product (23.2) from the mean (52.5). This value would ordinarily be exceeded 99.95 percent of the time in July. The value 3.29 is the number of standard deviations from the mean to the 99.95th percentile assuming a normal distribution.

Table 6.8. Procedures for Determining Answers To Sample Questions from the All-Months Relative Humidity Summary (Figure 6.9, page 49).

To Find	Pertinent Row/Column	Answer
Mean January relative humidity.	**Jan/Mean Relative Humidity**	**62.4%**
Mean May relative humidity.	**May/Mean Relative Humidity**	**59.8%**
Month with highest mean monthly relative humidity.	**Dec/Mean Relative Humidity**	**Dec**
Month with lowest mean monthly relative humidity.	**Aug/Mean Relative Humidity**	**Aug**
Mean annual percentage of time when the relative humidity is greater than 60 percent.	**Totals/60%**	**45.0**
Mean annual percentage of time when the relative humidity is less than or equal to 50 percent.	**Total/50%**	**37.2**
Mean percentage of the time that July relative humidity is greater than 90 percent.	**Jul/90%**	**1.6**

Table 6.8 - Continued

To Find	Pertinent Row/Column	Answer
Month with the highest percentage of relative humidity greater than 80 percent.	Apr and Nov/80%	Apr & Nov
Month with the highest percentage of relative humidity greater than 30 percent.	Jan/30%	Jan
Number of observations during the period of record (1967-1977) with relative humidity greater than 70 percent in November.	Nov/70%(Total No. of Obs)	2300[1]
Mean percentage of time in September with relative humidity less than or equal to 46 percent.	Sep/40% and 50%	54.9[2]

[1] The value 2300 is calculated by multiplying the percentage frequency of relative humidity of greater than 70 percent (0.32) by the total number of observations (7188).

[2] The percentage frequency of relative humidity greater than 46 percent (54.9) is approximated by linear interpolation.

Chapter 7

PRESSURE SUMMARY (PART F)

7.1 General

Part F of the RUSSWO contains two types of summaries, the Station Pressure Summary (Figure 7.1) and the Sea-Level Pressure Summary (Figure 7.2). The Station Pressure Summary contains means, standard deviations, and total observations of station pressure in inches of mercury for eight selected hours and for all hours of the day by month. The Sea-Level Pressure Summary includes the same statistical treatments and categories as the station pressure except that the pressure for mean sea level is expressed in millibars. Both summaries are derived from 3-hourly observations.

Monthly and annual station pressure and mean sea-level pressure distributions are near normal (Gaussian) although some positive or negative skewness occurs. Additionally, deviations from the normal distribution occur near the extremities of these pressure distributions. Unless great accuracy is desired, these pressure distributions can usually be considered as normal.

7.2 Definitions

For most stations located at airfields in the United States, station pressure is that pressure recorded at the station elevation which is defined in paragraph 7.2.1. Other elevations listed in various publications are often wrongly interpreted as this station elevation. The three types of elevation generally used are defined in paragraphs 7.2.1 through 7.2.3. Complete explanations on the various definitions can be found in the Federal Meteorological Handbook, No. 8 (1963) and current definitions can be found in WMO/OMM No. 9 (1983).

7.2.1 Station Elevation. Station elevation is the datum level to which barometric pressure reports at the station refer. These pressure values are called "station pressure" and are understood to refer to the given level for the purpose of maintaining continuity in the pressure records.

7.2.2 Field Elevation. Field elevation is the official elevation of an airport which is given for meteorological stations located at airports. This elevation is the highest point of the airport runway above mean sea level. This elevation is printed on the front cover of the RUSSWO. Field elevations can be found in the USAF/USN Flight Information Publication, Enroute Supplements (1983).

7.2.3 Barometer Elevation. Barometer elevation is the height above mean sea level at which the barometer (ivory point) at a station is positioned. Many stations not located at airfields and those located in or near cities in the United States use the barometer level as their reference point.

7.2.4 Climatological Station Elevation. Climatological station elevation is the elevation above mean sea level used as the reference datum level for all climatological records of atmospheric pressure in a given locality; it is not necessarily the same as station elevation. The reduction of pressure to this standard elevation is necessary only if a station has changed its specific location but has stayed within the general area so that the two or more sets of records remain comparable.

7.3 Exercises For the Station Pressures and Sea-Level Pressure Summaries

Tables 7.1 and 7.2 contain a variety of questions with procedures for determining answers from the Station Pressure Summary (Figure 7.1) and Sea- Level Pressure Summary (Figure 7.2), respectively. Many of the answers can be determined directly from the summary and others require additional supporting information to arrive at a solution. Extensive footnoting is used in cases which require supporting information to determine an answer. The exercises are intended only to acquaint the user with the type of information that can be gleaned from these data summaries and as such, are not intended to be comprehensive.

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MEANS AND STANDARD DEVIATIONS

STATION PRESSURE IN INCHES HG FROM HOURLY OBSERVATIONS

24006 ELLSWORTH AFB SD/RAPID CITY 67-77

STATION / STATION NAME / YEARS

HRS (LST)		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
02	MEAN	26.535	26.554	26.492	26.504	26.536	26.524	26.612	26.594	26.605	26.598	26.574	26.521	26.554
	S.D.	.216	.207	.204	.211	.173	.157	.141	.123	.182	.194	.206	.208	.192
	TOTAL OBS	301	273	304	297	303	290	286	306	297	299	288	302	3554
05	MEAN	26.525	26.545	26.486	26.502	26.538	26.533	26.621	26.599	26.606	26.594	26.575	26.513	26.553
	S.D.	.211	.209	.211	.212	.176	.157	.139	.127	.184	.199	.218	.207	.194
	TOTAL OBS	297	268	303	289	306	294	286	307	295	302	276	300	3523
08	MEAN	26.543	26.567	26.505	26.521	26.553	26.546	26.638	26.617	26.624	26.615	26.595	26.532	26.571
	S.D.	.213	.206	.213	.214	.178	.161	.138	.127	.181	.197	.205	.210	.194
	TOTAL OBS	301	275	298	292	304	294	289	306	290	301	266	297	3537
11	MEAN	26.546	26.572	26.502	26.516	26.542	26.537	26.641	26.608	26.613	26.608	26.587	26.539	26.567
	S.D.	.213	.210	.215	.213	.187	[illegible]	.215	.126	.184	.204	.209	.210	.201
	TOTAL OBS	304	275	304	297	305	299	289	301	294	299	288	304	3559
14	MEAN	26.515	26.537	26.475	26.495	26.517	26.512	[illegible]	26.575	26.575	26.570	26.556	26.504	26.536
	S.D.	.216	[illegible]	.212	.210	.184	.162	.134	.122	.180	.198	.207	.210	.192
	TOTAL OBS	299	278	299	269	301	295	289	299	286	302	291	307	3536
17	MEAN	26.531	26.548	26.478	26.489	26.505	26.496	26.584	26.560	26.574	26.577	26.568	26.523	26.535
	S.D.	.216	.202	.205	.206	.183	.157	.134	.120	.178	.194	.209	.206	.190
	TOTAL OBS	302	272	303	296	304	299	280	299	294	309	279	308	3537
20	MEAN	26.534	26.564	26.504	26.520	26.529	26.516	26.599	26.584	26.607	26.601	26.575	26.532	26.555
	S.D.	.220	.202	.201	.200	.178	.152	.135	.118	.176	.199	.212	.206	.189
	TOTAL OBS	290	274	307	293	302	294	285	301	290	301	289	304	3530
23	MEAN	26.539	26.503	26.505	26.521	26.541	26.532	26.620	26.599	26.613	26.602	26.580	26.532	26.562
	S.D.	.216	.203	.205	.207	.183	.156	.139	.122	.179	.199	.211	.207	.191
	TOTAL OBS	299	275	305	298	304	293	287	302	291	303	287	306	3548
ALL HOURS	MEAN	26.534	26.556	26.493	26.508	26.533	26.525	26.615	26.592	26.602	26.594	26.576	26.524	26.554
	S.D.	.215	.205	.208	.209	.180	.159	.150	.124	.181	.199	.210	.208	.193
	TOTAL OBS	2393	2190	2423	2351	2429	2367	2291	2421	2337	2412	2284	2426	28324

Figure 7.1. Means and Standard Deviations of Station Pressure in Inches Hg from Hourly Observations, 1967-1977.

Table 7.1. Procedures for Determining Answers To Sample Questions from the Station Pressure Summary (Figure 7.1, page 57).

To Find	Pertinent Row/Column	Answer
Mean January station pressure.	Mean (All-Hours)/Jan	26.534 in
Standard deviation of 0800 LST June station pressure.	S.D. (08)/Jun	0.161 in
Values of the October station pressure ranging from the 16th through the 84th percentile.	Mean and S.D. (All-Hours) Oct	26.397 to 26.795 in[1]
Mean annual station pressure in millibars.	Mean (All-Hours)/ Annual	899.23 mb[2]
The 0.05th percentile lowest May station pressure.	Mean and S.D. (All-Hours)/May	25.941 in[3]
The 99.95th percentile highest May pressure altitude.	See Footnote 4 Below	3900 ft
Mean annual 0500 LST station pressure.	Mean (05)/Annual	26.533 in
Mean 1400 LST July pressure altitude.	See Footnote 5 Below	+3200 ft

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MEANS AND STANDARD DEVIATIONS

SEA LEVEL PRESSURE IN MBS FROM HOURLY OBSERVATIONS

24006 ELLSWORTH AFB SD/RAPID CITY 7-77

STATION STATION NAME YEARS

HRS (L.S.T.)		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
02	MEAN	1017.7	1017.3	1013.9	1012.9	1012.7	1011.1	1013.6	1012.9	1014.6	1015.6	1016.8	1016.3	1014.6
	S D	9.933	8.845	9.053	8.826	7.313	6.423	5.793	5.147	7.641	8.478	8.664	8.884	8.273
	TOTAL OBS	310	283	310	299	310	300	310	310	300	310	299	310	3651
05	MEAN	1017.7	1017.4	1014.0	1013.1	1013.0	1011.5	1014.1	1013.3	1014.9	1016.2	1017.3	1016.5	1014.9
	S D	9.801	8.806	9.144	8.772	7.279	6.361	5.732	5.260	7.682	8.426	8.654	8.716	8.225
	TOTAL OBS	310	283	310	300	309	302	310	310	300	310	300	310	3652
08	MEAN	1018.4	1018.3	1014.9	1013.8	1013.4	1011.9	1014.5	1013.9	1015.5	1016.9	1018.3	1017.3	1015.6
	S D	9.754	8.735	9.108	8.774	7.313	6.442	5.657	5.257	7.674	8.321	8.592	8.844	8.246
	TOTAL OBS	310	283	310	300	310	300	310	310	300	310	300	310	3653
11	MEAN	1018.3	1018.1	1014.4	1013.4	1012.9	1011.5	1014.1	1013.4	1014.9	1016.2	1017.5	1017.1	1015.1
	S D	9.801	8.779	9.178	8.794	7.468	6.468	5.643	5.208	7.729	8.381	8.689	8.866	8.309
	TOTAL OBS	310	283	310	300	310	300	310	310	300	310	300	310	3653
14	MEAN	1016.7	1016.5	1013.1	1012.4	1011.9	1010.5	1013.2	1012.2	1013.6	1014.8	1016.0	1015.6	1013.9
	S D	9.853	8.700	9.131	8.653	7.462	6.489	5.565	5.095	7.591	8.260	8.605	8.851	8.189
	TOTAL OBS	309	283	310	300	310	300	310	309	300	310	300	310	3651
17	MEAN	1017.8	1017.2	1013.6	1012.4	1011.6	1010.0	1012.5	1011.7	1013.6	1015.5	1017.1	1016.9	1014.1
	S D	9.839	8.560	8.891	8.484	7.497	6.271	5.532	5.032	7.486	8.196	8.620	8.691	8.262
	TOTAL OBS	310	283	310	300	310	300	309	310	300	309	299	310	3650
20	MEAN	1018.4	1018.2	1014.9	1013.4	1012.5	1010.7	1013.1	1012.6	1014.8	1016.8	1017.6	1017.3	1015.0
	S D	9.938	8.636	8.727	8.495	7.291	6.110	5.479	4.903	7.440	9.292	8.769	8.708	8.227
	TOTAL OBS	310	283	310	300	308	299	310	309	300	310	298	310	3647
23	MEAN	1018.0	1017.6	1014.6	1013.6	1013.0	1011.3	1013.8	1013.1	1014.9	1016.1	1017.1	1016.9	1015.0
	S D	10.036	8.688	8.970	8.629	7.361	6.293	5.728	5.069	7.523	8.513	8.865	8.833	8.242
	TOTAL OBS	310	283	310	300	309	299	309	308	300	310	299	310	3647
ALL HOURS	MEAN	1017.9	1017.6	1014.2	1013.1	1012.6	1011.1	1013.6	1012.9	1014.6	1016.0	1017.2	1016.7	1014.8
	S D	9.870	8.725	9.033	8.681	7.385	6.375	5.667	5.159	7.612	8.370	8.494	8.805	8.261
	TOTAL OBS	2479	2264	2480	2399	2476	2399	2478	2476	2400	2479	2395	2480	29204

Figure 7.2. Means and Standard Deviations of Sea-Level Pressure in MB from Hourly Observations, 1967-1977.

1 The required pressures are obtained by adding to and subtracting from the mean (26.596) one standard deviation (0.199).

2 The beginning of Part F of all RUSSWOs has a pressure altitude versus barometric pressure scale. It can also be used to convert pressures in inches of mercury to millibars. For more accurate conversion, use 1 inch = 33.864 millibars.

3 In a normal distribution the 0.05th percent lowest value is determined by multiplying the standard deviation (0.180) by 3.29 and subtracting the product (0.592) from the mean (26.533). This value would ordinarily be exceeded 99.95 percent of the time in May.

4 This value is found by entering the pressure altitude-barometric pressure scale at the beginning of each F Summary with 25.941 inches found in the previous exercise. A more accurate answer is 3897 feet which can be found by consulting FMH-8 (USWB 1963) or the US Standard Atmosphere, 1962. Simply enter the appropriate table with the given pressure to find the equivalent pressure altitude. A value greater than the pressure altitude found has a chance of occurring only 0.05 percent of the time.

5 Use the pressure altitude-barometric pressure scale. Enter with the mean station pressure at 1400 LST in July (26.606). The scale, of course, is very crude and tables should be used for greater accuracy.

Table 7.2. Procedures for Determining Answers To Sample Questions from the Sea-Level Pressure Summary (Figure 7.2, page 58).

Table 7.2 - Continued

To Find	Pertinent Row/Column	Answer
Mean November sea-level pressure.	Mean (All-Hours)/Nov	1017.2 mb
Mean sea-level pressure at 1700 LST in February in inches Hg.	Mean (17)/Feb	30.038 in[1]
January hour (LST) with the lowest mean of the sea-level pressure.	Mean (14)/Jan	1400
Annual Hour (LST) with the greatest standard deviation.	Mean (11)/Annual	1100
August hour (LST) with the smallest standard deviation.	S.D. (20)/Aug	2000
Values of the April sea-level pressure spanning the 16th through 84th percentile.	Mean and S.D. (All-Hours)/April	1004.4 to 1021.8 mb[2]
The 0.05th percent lowest May sea-level pressure.	Mean and S.D. (All-Hours)	988.3 mb[3]
The 99.95th percent highest May pressure altitude at station.	See Footnote 4 Below	3966 ft
The 50th percentile of the 0500 LST sea level January pressure.	Mean (05)/Jan	1017.7 mb[5]
Month with the lowest mean sea-level pressure.	Mean (All-Hours)/Jun	Jun
Month with the highest mean sea-level pressure	Mean And S.D. (All-Hours)/Jan	Jan
Greatest hourly standard deviation.	S.D. (23)/Jan	10.036
Value of the November sea-level pressure which has a probability of being exceeded 16 percent of the time.	Mean And S.D. (All-Hours)/Nov	1025.9[6]

[1] At the beginning of Part F of all RUSSWOs is a pressure altitude versus pressure scale. It can also be used to convert pressures in millibars of mercury to inches. For more accurate conversion, use one millibar equals 0.02953 inches of mercury.

[2] The required sea-level pressures are obtained by adding to and subtracting from the mean (1013.1) one standard deviation (8.681). We assume a normal distribution of sea-level pressure.

[3] In a normal distribution, the 0.05th percent lowest value is determined by multiplying the standard deviation (7.385) by 3.29 and subtracting the product (24.30) from the mean (1012.6). This value would ordinarily be exceeded 99.95 percent of the time in May.

[4] The answer can be closely approximated by entering the pressure altitude-barometric pressure scale with 988.3 millibars (29.184 inches of mercury), obtaining the pressure altitude (690 feet) and algebraically adding to it the field elevation (3276 feet). Compare this value with that determined in Table 7.1 from the station pressure.

[5] In a normal distribution the 50th percentile is identical with the mean.

[6] The 84th percentile satisfies the criterion. Hence, the sought-after value is the mean plus one standard deviation.

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- Part D: Ceiling versus Visibility; Sky Cover.
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